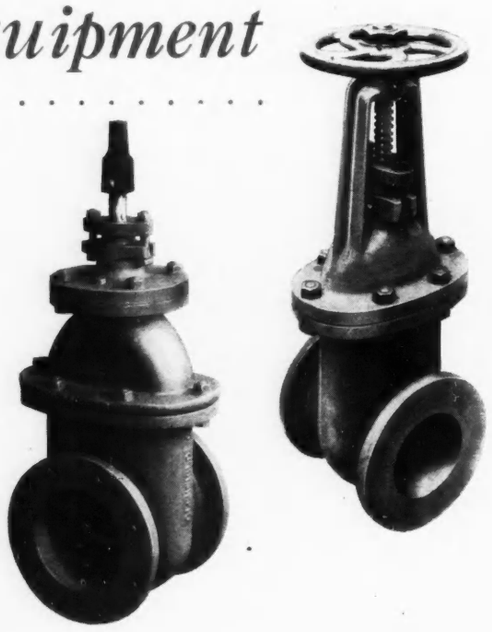
OLOGY DEPT.

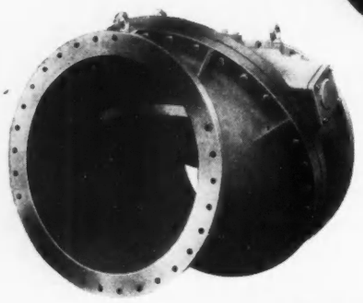
The Engineer

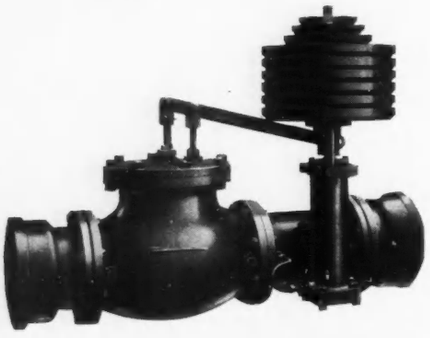
AUGUST 23, 1957 — 28 ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

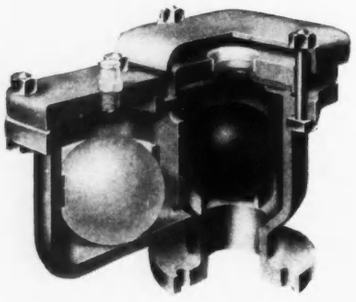
RARY
57

If it's equipment









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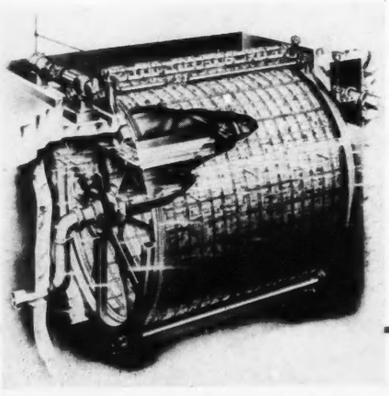

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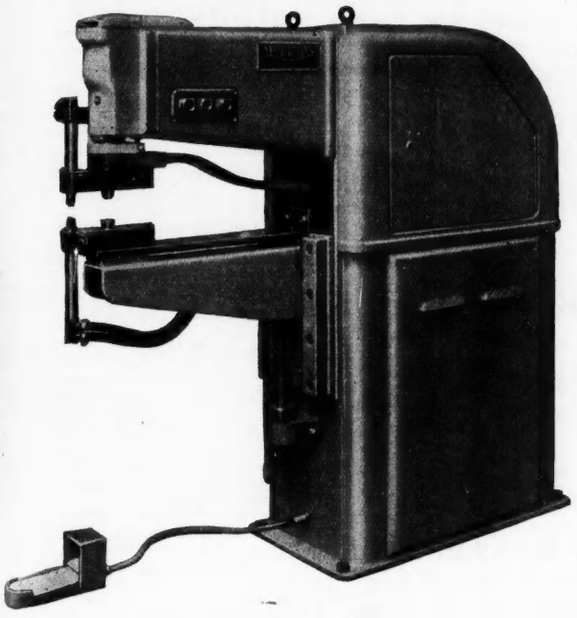

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Write for Descriptive Leaflet 783/21-1 *for full details*

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THE ENGINEER

ESTABLISHED 1856

28 ESSEX STREET, STRAND, LONDON, W.C.2.

Telephone: CENtral 6565

Vol. 204 No. 5300

AUGUST 23, 1957

Published every Friday Registered as a Newspaper

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NOTICE TO READERS
All letters intended for insertion in "The Engineer" or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

SUBSCRIPTIONS
U.K. and ABROAD £5 10. 0. per annum, including postage (CANADA £5 5. 0.) Single copies 2s. each, plus 6d. postage. Also on sale at newsagents.

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Published by
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PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY AUTHORITY

HEADQUARTERS—LONDON

THIRD ASSISTANT ENGINEER

A vacancy exists for a THIRD ASSISTANT ENGINEER in the Boiler Plant Section of the Plant Design Branch in the Chief Engineer's Department in London.

Duties will be to assist in technical and economic investigations in relation to boiler plant and ancillary equipment.

Candidates should have an engineering degree or equivalent qualification and experience in the manufacture of power station boilers; preference will be given to those with estimating experience.

Salary within Scale £1105–£1315 p.a.

Write for application form to Director of Establishments, Central Electricity Authority, Applications Section, Winsley Street, London, W.1. Forms to be completed and returned by 13th September. Quote Ref. ENR/366. E8070

MALAYAN RAILWAY

MECHANICAL ENGINEERS

To take charge of: (a) a group of Railway Workshops engaged in the repair of locos, the building and repair of coaching and goods stock and the maintenance of mechanical plant and equipment, or (b) a District in the Loco. Operating Branch, including the supervision of Running Sheds, and the running maintenance of locos., carriages, wagons and marine craft.

Three years' contract appointment. Salary range: £1145–£2378, point of entry depending on experience. Substantial cost-of-living allowance. Gratuity of £232 to £324 per annum.

Free passages for officer, wife and three children under 12. Quarters, if available, at reasonable rents, or housing allowance in lieu.

Candidates must be A.M.I.Mech.E. or have passed or be exempt from Parts I and II of the examination for A.M.I.Mech.E.

Write, Director of Recruitment, Colonial Office, S.W.1, stating age, qualifications and experience. Quote BCD 110/23/07. E8061

CLASSIFIED ADVERTISEMENTS

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Copy Date. "Run-on" and "Semi-Displayed"—by noon on Tuesday for publication on Friday of the same week.
"Displayed" and "Illustrated"—by noon on Friday for publication on the following Friday.

For styles and sizes of "Run-on", "Semi-Displayed", "Displayed" and "Illustrated" Classified Advertisements please send for Circular.

Advertisements for publication should be addressed to:—
Classified Advertisement Dept.,
"The Engineer", 28 Essex Street, Strand, London, W.C.2.
***Urgent advertisements may be telephoned to* CENtral 6565.**

E. R.

By Order of the Minister of Supply

GOVERNMENT SURPLUS STORES

TO BE SOLD BY AUCTION

AUCTION PROGRAMME

		Main Location of Stores	Auctioneers
August 28–30	Machine tools and miscellaneous stores, including a large number of industrial sewing machines	Central Ordnance Depot, Old Dalby, Melton Mowbray, Leicestershire. (Sale at Melton Mowbray.)	SHOULER & SON (Dept. L), 1, Norman St., Melton Mowbray, Leicestershire. (Tel. 81.)
September 4	Miscellaneous stores, including furniture, kitchen utensils, barrows, bicycle spares, canvas	General Stores Sub-Depot, Longtown, Nr. Carlisle	HARRISON & HETHERINGTON LTD. (Dept. L), Botchergate, Carlisle (Tel. 26292/3.)
September 3–6	Vehicles, lifting and earth moving equipment	M.O.S. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel. 47271.)
September 10–13	*Vehicles, machine tools and miscellaneous stores	M.O.S. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18.	FULLER, HORSEY SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel. Royal 4861.)
September 17–18	Miscellaneous stores, including large quantity of motor tyres	M.O.S. Storage Depot, Rotherwas, Hereford	RUSSELL, BALDWIN & BRIGHT, LTD. (Dept. L), 20, King St., Hereford (Tel. 4366.)

* Jeeps, saloons, water tankers, light and heavy G.S. Trucks, vans (some Diesels), utilities, and trailers, lathes, vertical drilling machines, milling machines, hacksawing machines, weighbridges, overhead electric travelling cranes, concrete breakers, diesel-electric generating sets, air compressors, pneumatic hand tools, telephone, radio and electrical equipment, diesel and petrol engines, 4000 binoculars, 7000 telescopes, 900 rolls coir matting, clothing and women's shoes, medical and chemical equipment, survey equipment, &c.

CATALOGUES (6d. each—P.O.s only) available from the Auctioneers shown above. E975

PUBLIC APPOINTMENTS

NEW ZEALAND MINISTRY OF WORKS

PROFESSIONAL & TECHNICAL STAFF

The Ministry of Works, New Zealand, invites applications for the following vacancies on the permanent staff. Positions, qualifications desired and commencing salaries are as follows :—

CIVIL ENGINEERING DIVISION.

1. ENGINEERS.—Corporate Membership of the Institution of Civil Engineers, London. Commencing salaries from £895 to £1465 per annum.

2. ASSISTANT ENGINEERS.—A University Degree in Civil Engineering which gives exemption from Final Parts I and II of the A.M.I.C.E. examination or an equivalent examination. Commencing salaries from £810 to £1000 per annum.

3. ENGINEERING ASSISTANTS.—General Certificate of Education standard or equivalent and eight years' practical experience. Commencing salaries £810 to £1080 per annum.

4. DRAUGHTSMEN.—Ordinary or Higher National Certificate or equivalent and at least three years' experience at the drawing board. Commencing salary up to £1150 per annum in accordance with qualifications and experience.

MECHANICAL ENGINEERING DIVISION.

5. MECHANICAL & ELECTRICAL ENGINEERS.—Corporate Membership of the Institutions of Mechanical or Electrical Engineers, London, whichever is appropriate. Commencing salaries £895 to £1465 per annum.

6. BUILDING SERVICES ENGINEERS.—Corporate Membership of the Institution of Mechanical Engineers or of the Institution of Heating and Ventilating Engineers, London. Commencing salaries £895 to £1465 per annum.

7. ASSISTANT MECHANICAL, ELECTRICAL OR BUILDING SERVICES ENGINEERS.—A University Degree in Mechanical or Electrical Engineering or Graduate Membership of the above Institutions. Commencing salaries £810 to £1000 per annum.

8. MECHANICAL, ELECTRICAL OR BUILDING SERVICES DRAUGHTSMEN.—Ordinary or Higher National Certificate in Mechanical or Electrical Engineering or equivalent examination, and at least three years' experience in draughting, design and calculations. Commencing salaries £720 to £1000 per annum.

Inquiries, mentioning this paper and quoting reference No. 3/74/133, also stating the type and number of position sought, should be addressed to the High Commissioner for New Zealand, 415, Strand, London, W.C.2. Full details of duties, experience desired, and general information on the conditions of employment in the New Zealand Public Service, together with application forms, will then be furnished. E7820

CENTRAL ELECTRICITY AUTHORITY

EASTERN DIVISION

SENIOR DRAUGHTSMEN (MECHANICAL)

Applications are invited for the following appointments : SENIOR DRAUGHTSMEN (Mechanical), Generation (Construction) Department at Divisional Headquarters.

Salary N.J.B., Schedule " D," Grades 4/5, £800–£1045 per annum.

The commencing salary will depend upon experience and qualifications, but will be within the above range.

Applicants must have had experience in mechanical plant layout, pipework design.

Applications, stating age, qualifications, experience and present position, should be addressed to the Controller, Central Electricity Authority, Eastern Division, West Farm Place, Chalk Lane, Cockfosters, Barnet, Herts.

W. N. C. CLINCH,
Controller.
E928

BRACKNELL DEVELOPMENT CORPORATION

STRUCTURAL ENGINEER

Applications are invited for the appointment of STRUCTURAL ENGINEER on the Staff of the Chief Architect. Salary Grade : £1100 by £55 (4) to £1320. Applicants should be Corporate Members of the Institution of Structural Engineers and have had good all-round experience. The successful applicant will be required to advise the Chief Architect on matters relating to structural work and foundations to buildings, including factories, public buildings, &c., to prepare designs and supervise the specialist works.

Superannuation schemes. Medical examination. Housing available in due course.

Apply by 3rd September, 1957, giving age, education and qualifications, experience and appointments held (with dates and salaries) and two referees, to General Manager (S.E.), Bracknell Development Corporation, Farley Hall, Bracknell, Berkshire. E8006

BRITISH TRANSPORT WATERWAYS

NOTTINGHAM

DRAUGHTSMAN

British Transport Waterways require DRAUGHTSMAN at Nottingham. Applicants should have experience in one or both of the following :—(a) General civil engineering works, preferably as applied to river and canal ; (b) surveying. Salary £775/£850, superannuation fund and certain privilege railway travel facilities.—Applications, stating age, experience and qualifications, to Staff and Establishment Officer, 163, Euston Road, London, N.W.1, by 21st August. E8022

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY AUTHORITY

EASTERN DIVISION

CIVIL AND STRUCTURAL DESIGNER DRAUGHTSMEN

Applications are invited for the following posts at Divisional Headquarters, Cockfosters, adjacent to Cockfosters Station (Piccadilly Line) :—

CIVIL AND STRUCTURAL DESIGNER DRAUGHTSMEN

Salary : N.J.B., Schedule " D," within the range of Grades 4/5, £800 by £20 to £945 per annum, including London Weighting.

The commencing salary will depend on experience and qualifications.

New offices recently completed in pleasant surroundings, excellent working conditions. Canteen available. Sports and social club. Sick pay and superannuation schemes. Generous holidays.

The candidates appointed will be required to undertake civil and structural design work, and applicants should have had experience in the design and detailing of reinforced concrete structures for heavy plant, culverts, &c., and structural steelwork as applied to industrial buildings.

Applications, stating age, qualifications and experience, should be sent to the Controller, Central Electricity Authority, Eastern Division, West Farm Place, Chalk Lane, Cockfosters, Barnet, Herts.

W. N. C. CLINCH,
Controller.
E974

MANCHESTER CORPORATION WATERWORKS UNDERTAKING

ASSISTANT ENGINEER (CLASS I)

Applications are invited for the appointment of ASSISTANT ENGINEER (Class I), to be employed on the design and construction of two large rapid gravity filtration plants and associated treatment works, at a commencing salary within the range of £1000/£1350 per annum, according to qualifications and experience.

Housing accommodation is available at a reasonable rental.

Applicants must be Corporate Members of the Institution of Civil Engineers and have experience o the construction of large-scale civil engineering works. The appointment will be to the temporary staff and is superannuable.

Applications, stating age, education and training, professional qualifications and experience, together with the names of two referees, should be addressed to the Engineer and Manager, Waterworks Offices, Town Hall, Manchester, 2, so as to be received by 16th September, 1957. E8042

CIVIL SERVICE COMMISSION

CIVIL ENGINEERS : STRUCTURAL ENGINEER

The Civil Service Commissioners invite applications for pensionable posts.

Age at least 25 and under 35 on 1st January, 1957, with extension for regular Forces service and appropriate Civil Service.

Candidates must : (i) have achieved Corporate Membership of the Institution of Civil Engineers or the Institution of Structural Engineers, for the Structural Engineer post, and, for some posts, have qualified in certain subjects, or (ii) have passed, or been exempted from, examinations necessary for obtaining Corporate Membership ; such candidates would be expected to qualify under (i) in due course. Professional experience expected.

London salary scale (men) : £805 (at age 25) to £1250. Starting salary according to age, up to £1085 at 34 or over. Lower rates outside London. Prospects of promotion to higher grades on salary scale £1280–£1720 and £1780–£2050 and above. Women's salaries lower but being raised to reach equality with men's by 1961.

Further particulars and application forms from Civil Service Commission, Scientific Branch, 30, Old Burlington Street, London, W.1, quoting No. S64–65/57.

Interview Boards held at intervals, as required. Early application advised. E8062

NATIONAL COAL BOARD

CIVIL/STRUCTURAL ENGINEERS

Posts are open in the West Midlands Divisional Coal Board's service at their Headquarters near Dudley for the following :

SENIOR CIVIL/STRUCTURAL ENGINEER

Corporate Membership of the Institution of Civil or Structural Engineers ; wide experience in the design and construction of large civil engineering works (including heavy foundations, roads and drainage, structures in reinforced concrete and structural steel and railway sidings, preferably in connection with collieries) ; ability to prepare contract documents, specifications and bills of quantities are required.

Salary within the range £925–£1425, according to qualifications and experience.

CIVIL/STRUCTURAL ENGINEERS

Requirements are Corporate Membership of the Institution of Civil or Structural Engineers ; experience in the design and construction of some of the following : heavy foundations, roads and drainage, structures in reinforced concrete and structural steel, railway sidings. Experience in preparation of contract documents, specifications and bills of quantities an advantage.

Salary within the range £800–£1225.

Applications, quoting EN, on forms obtainable from the Divisional Chief Staff Officer, West Midlands Divisional Coal Board, Himley Hall, Dudley, Worcs., by September 5, 1957. E8055

PUBLIC APPOINTMENTS

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

RISLEY, WARRINGTON

ENGINEERS

Vacancies exist in the Inspection and Progress Department of the Engineering Branch of the Industrial Group of the United Kingdom Atomic Energy Authority at its Headquarters at Risley, Warrington, Lancashire.

DUTIES :—Control of the Inspection and Progressing of the manufacture at contractors' works of a wide variety of plant, equipment, material and stores. These duties involve close liaison with design and construction engineers. Considerable travelling in the United Kingdom will be involved.

QUALIFICATIONS AND EXPERIENCE :—

Applicants must have served a recognised engineering apprenticeship or pupilage and have Corporate Membership of a Senior Engineering Institution, or have equivalent qualifications. They should have experience in planning, design, production or inspection of medium or heavy plant, and be capable of inspecting and programming work through contractors' shops and of assisting contractors with production capacity and material difficulties.

SALARY :—Will be assessed within the scale £1300–£1740 p.a.

A contributory pension scheme is in operation.

Authority houses for renting by successful married candidates may be available in due course, or, alternatively, substantial assistance may be given towards legal expenses incurred in private purchase.

Send a postcard for an application form, quoting reference 2023, to the Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancs.

Closing date, 9th September, 1957. E8033

NATIONAL COAL BOARD

NORTHERN (N. & C.) DIVISIONAL HEADQUARTERS

DIVISIONAL MECHANICAL ENGINEER

DIVISIONAL MECHANICAL ENGINEER required for National Coal Board, Northern (N. & C.) Divisional Headquarters, Newcastle-upon-Tyne. Applicants should be Corporate Members of a professional body or possess equivalent technical qualifications. Preference will be given to applicants who have some practical experience in mechanical plant and equipment and are conversant with the design, installation, operation and maintenance of surface and underground mechanical plant and machinery. They should have held previous posts requiring engineering administrative responsibility. Salary within the range £1750–£2500 per annum, according to qualifications and experience.

Applications, giving date of birth and full details of education, qualifications and experience, to Staff Director, National Coal Board, Northern (N. & C.) Division, Whitley Road, Longbenton, Newcastle-upon-Tyne, 12, by 5th September, 1957. Please quote E/3. E8064

NEW SOUTH WALES, AUSTRALIA

DEPARTMENT OF MAIN ROADS

CIVIL ENGINEERS

Applications are invited from graduates (or undergraduates in their final year) in Civil Engineering of a recognised British or Irish University for appointment to the staff of the Department of Main Roads, New South Wales, the State Road Authority for construction of roads and bridges.

On appointment, applicants may be engaged at the Department's Head Office, Sydney, on the design of reinforced concrete and steel bridges or on main road construction and maintenance either in the metropolitan area or the country.

Commencing salary according to qualifications and experience will be within the range £A1085 to £A1338 per annum, with annual progression, subject to technical competence, to £A1624 per annum. Appointees will be eligible to contribute to the State Superannuation Fund after six months.

Appointee's full fare from England to Australia will be met by the Department, subject to a three year's service guarantee bond being completed. Appointment will be subject to satisfactory medical examination and preference will be given to applicants not more than 30 years of age.

Applications should be made on forms obtainable from the Agent General for New South Wales, 56, Strand, London, W.C.2. E8067

THURROCK U.D.C.

ENGINEER AND SURVEYOR'S DEPARTMENT (SEWAGE DISPOSAL SECTION)

WORKING FOREMAN

Thurrock U.D.C. (Engineer and Surveyor's Dept. (Sewage Disposal Section)) require WORKING FOREMAN. Applicants should be experienced in maintenance of sewage works and pumping stations, and control of labour, and must be competent Fitters and Turners. Knowledge of heavy oil engines advantageous. Salary : Misc. Grade VI, £620 2s. 6d.–£686 15s. per annum. Successful applicant required to live in bungalow, for which a rent of 6s. 6d. per week, exclusive of rates, will be charged. 7s. per week allowed in respect of electricity consumed. Appointment pensionable.

Applications, together with names and addresses of two referees, to Clerk of the Council, Council Offices, Grays, Essex, by 10th September, 1957. Canvassing disqualifies. Relationship with any member or Senior Officer of the Council must be disclosed. E8060

PUBLIC APPOINTMENTS

CIVIL SERVICE COMMISSION

SENIOR SCIENTIFIC OFFICERS; SCIENTIFIC OFFICERS

The Civil Service Commissioners invite applications for pensionable appointments covering a wide range of scientific research and development in most of the major fields of fundamental and applied science. In Biological subjects the number of vacancies is small : individual vacancies exist in the Natural History Museum for candidates who have special knowledge of, or who are interested in, crystallography, taxonomic entomology, palaeobotany, malacology, acarology.

SCIENTIFIC OFFICERS are urgently required for the Forensic Science Laboratories ; for scientific examination of document and hand-writing cases at Cardiff : for CHEMISTS at Preston, Harrogate and in London. There is also a vacancy for a SENIOR SCIENTIFIC OFFICER (BIOLOGIST) at Harrogate.

The Royal Naval Scientific Service require a SCIENTIFIC OFFICER (male) for the National Institute of Oceanography, to work on oceanic Cephalopoda.

Candidates must have obtained a University Degree with First or Second Class Honours in an appropriate Scientific subject (including Engineering) or in Mathematics, or an equivalent qualification, or be otherwise qualified by high professional attainments. Candidates for Senior Scientific Officer posts must, in addition, have had at least three years' post-graduate or other approved experience.

Age Limits : Senior Scientific Officers, between 26 and 31, but specially suitable candidates under 26 may be admitted ; for Scientific Officers between 21 and 28 during 1957 (up to 31 for permanent members of the Experimental Officer class). Salary : (London) Senior Scientific Officers, minimum £1190 (women £1098). Men's scale maximum £1410. Scientific Officers : minimum £635. Men's scale maximum £1110. Women's pay above £635 slightly lower but being raised to reach equality with men's in 1961. Somewhat lower rates in the provinces. 5-day week, generally.

Further particulars from Civil Service Commission, Scientific Branch, 30, Old Burlington Street, London, W.1, quoting No. S.53/57 for Senior Scientific Officers and S.52/57 for Scientific Officers.

Interview Boards will sit at intervals, as required. Early application is advised. E8063

EAST ANGLIAN REGIONAL HOSPITAL BOARD

ENGINEERS AND DRAUGHTSMEN

Applications invited from suitably qualified persons for a range of (1) mechanical and (2) electrical engineering posts for work in connection with development and design of a large new hospital and general hospital services for the whole region.

Posts are permanent and pensionable, providing scope in the entire field of hospital engineering covering surveys, reports, estimates, preparation of plans and specifications and supervision of site works undertaken by contract in connection with (1) heating, ventilating, air conditioning, boiler plant, kitchens and laundries, water supplies, &c., and (2) lighting, power, call, radio, fire alarm, telephone and clock systems, lifts, emergency supplies and electrical services in connection with (1). Hospital experience, although desirable, is not essential.

All grades of staff are required, ranging from Senior Assistants to Draughtsmen. Applications, giving full personal details of experience, qualifications, present salary, &c., with names of two referees, to Secretary of Board, 117, Chesterton Road, Cambridge, by 30th August, 1957. E7968

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION

ABSTRACTORS

The British Shipbuilding Research Association invites applications for ABSTRACTORS (Male or Female). The duties will consist mainly of abstracting and summarising technical and scientific papers in shipbuilding, marine engineering, naval architecture, general physics and engineering, and also dealing with technical enquiries relating to published material in these fields. A Degree in Engineering or Physics is desirable, but persons without degrees, suitably qualified otherwise, will also be considered. A reading knowledge of one or more of the following languages is desirable : German, Spanish, Italian, French, Dutch, Russian, Scandinavian languages.

The commencing salaries will depend upon age and qualifications. Superannuation under F.S.S.U.

Please apply, giving full details of career and qualifications, to B.S.R.A., 5, Chesterfield Gardens, Curzon Street, London, W.1. E8046

NATIONAL COAL BOARD

SOUTH WESTERN DIVISION

MECHANICAL ENGINEERING ASSISTANT

The National Coal Board, South Western Division, invite applications for the post of MECHANICAL ENGINEERING ASSISTANT, E.G.4, in the No. 5 (Rhymney) Area.

Applicants should possess a Higher National Certificate or equivalent qualification, and experience in the preparation and submission of major projects would be an advantage.

Salary range : £975–£1650 per annum.

Applicants who applied for the previous Vacancy No. 307 need not reapply.

Please quote S.V. No. 385.

Full particulars of age, qualifications, experience and positions held, together with details of present post and salary, should be sent to the Divisional Chief Staff Officer, National Coal Board, Cambrian Buildings, Mount Stuart Square, Cardiff, by 5th September, 1957. E8038

Classified Advts. continued on page 4

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY AUTHORITY HEADQUARTERS

CATHODIC PROTECTION

An opportunity arises to join a specialist team associated with the Research Sub-Department of the Chief Engineer's Department at London Headquarters. The duties consist of field work in relation to corrosion prevention on a wide range of buried and/or immersed plant, and are likely to involve a considerable amount of travel. Experience of corrosion engineering desirable, but not essential, and candidates should have a Degree or similar qualification in Engineering or Science. Salary for the appointment would be within the scale of £870–£1045 p.a.

Application forms obtainable from the Secretary's Office (Establishments), Applications Section, Winsley Street, London, W.1, should be completed and returned not later than 14th September. Quote ref. ENR/357. E8032

SOUTH-EAST METROPOLITAN REGIONAL HOSPITAL BOARD

APPOINTMENTS

Applications are invited for the following posts in the Regional Engineer's office :—

(1) SENIOR ASSISTANT ENGINEER (Mechanical). Salary £1060–£1245, inclusive of London weighting allowance ; superannuable. Candidates must be Corporate Members of the Institution of Mechanical Engineers and have experience in the preparation of large steam boiler and other complex engineering schemes.

(2) ASSISTANT ENGINEER (Mechanical), and

(3) ASSISTANT ENGINEER (Electrical). Salary in each case £730–£1065 inclusive of London weighting allowance ; superannuable. Candidates should possess appropriate professional qualifications and have experience in the preparation of (mechanical) heating and ventilating and other mechanical engineering schemes, and (electrical) electric light and power and other electrical engineering schemes.

Applications, stating age, qualifications and experience, with names of three referees, should reach the Secretary, 11, Portland Place, W.1, by 6th September. E8079

YORKSHIRE ELECTRICITY BOARD

NO. 5 (WAKEFIELD) SUB-AREA

SENIOR DRAUGHTSMAN (CIVIL AND BUILDING)—2 POSTS

Applicants should have had a good general and technical education at least to O.N.C. standard. They will be required to prepare drawings of substations, offices, building alterations, &c., and should have had drawing-office experience in the design of buildings and in civil engineering work.

Salary : N.J.B. Schedule D, Grade 5, £760/£20/£860 per annum.

Applications, giving full details of age, qualifications and experience, together with the names of two referees, should be forwarded to the Manager, No. 5 (Wakefield) Sub-Area, Yorkshire Electricity Board, 1a, Denby Dale Road, Wakefield, not later than 5th September, 1957. E8039

BOROUGH OF POOLE

WATER UNDERTAKING

ASSISTANT PUMPING SUPERINTENDENT

Applications invited from persons not exceeding 35 years of age for the appointment of ASSISTANT PUMPING SUPERINTENDENT at the Corfe Mullen Pumping Station, Wimborne. Salary in Grade Miscellaneous V (£574 rising to £635 10s per annum), plus house, rent and rates free. Subject to Scheme for Miscellaneous Classes, Superannuation Acts and satisfactory medical examination.

Candidates should have served apprenticeship as mechanics and have a knowledge of electrical and steam pumping plant.

Application forms and further particulars from Water Engineer and Manager, Municipal Buildings, Poole. Forms to be sent to the undersigned not later than Wednesday, the 11th September, 1957.

(Signed) J. G. HILLIER,
Municipal Buildings, Town Clerk.
Poole, Dorset. E7971

PUBLIC APPOINTMENTS

CIVIL SERVICE COMMISSION

INLAND REVENUE

THIRD CLASS VALUERS

The Civil Service Commissioners invite applications from professionally qualified VALUERS for Valuation Office in England and Wales and in Scotland. Some posts, except in Scotland, are for the valuation of minerals, plant and machinery. For these posts candidates must have 4 years' experience of mining and a First Class Certificate of Competency (Mine Managers), or have achieved Corporate Membership of the Royal Institution of Chartered Surveyors, accompanied by the passing of the final examination of this body in the Mining subdivision. Age at least 25 on 1st October, 1957. Starting salary for men in London : £805 (at age 25) up to £1165 at 36 or over. Maximum £1250. Women's scales lower, but being improved to reach equality with the men's scales by 1961. Somewhat lower rates in provinces.

Particulars and application forms from Secretary, Civil Service Commission, 6, Burlington Gardens, London, W.1, quoting No. 149/57. Completed application forms should be returned by the 26th September, 1957. E8074

SOUTH WARWICKSHIRE HOSPITAL GROUP

DEPUTY SUPERINTENDENT ENGINEER

DEPUTY SUPERINTENDENT ENGINEER required, to assist Superintendent Engineer over whole range of duties. Applicants should have served apprenticeship in mechanical engineering, and had thorough experience of institutional engineering, boiler plant, electrical and engineering services in general, building and maintenance work, supervision of contract and direct labour undertakings, together with general administration and record keeping, is required.

Applicants should possess the Extra First Class or First Class M.O.T. Certificate, or higher Diploma or Certificate in Mechanical Engineering or equivalent qualification.

Salary scale £775 by £25 (1) by £20 (1) by £25 (1) by £30 (2) to £905. Ministry of Health superannuation scheme.—Applications, giving names and addresses of three referees, to Group Secretary, 50, Holly Walk, Leamington Spa, by the 7th September. E8077

SOUTH-EAST METROPOLITAN REGIONAL HOSPITAL BOARD

DEPUTY REGIONAL ENGINEER

South-East Metropolitan Regional Hospital Board invites applications for the post of DEPUTY REGIONAL ENGINEER (salary £1395 by £55 (2) by £50 (2) by £35 (1) to £1640, inclusive of London weighting allowance) ; superannuable. The successful candidate will be required to act for the Regional Engineer over the whole range of the services for which the Engineer is responsible, and must have extensive professional and technical experience and full professional qualifications and status.—Applications, stating qualifications and experience, with names of three referees, should reach the Secretary, 11, Portland Place, W.1, by 6th September. E8078

ROYAL NATIONAL ORTHOPAEDIC HOSPITAL

RESIDENT ENGINEERING CRAFTSMAN

RESIDENT ENGINEERING CRAFTSMAN required, with maintenance experience in heating, domestic and ventilating equipment. Electrical experience an advantage. Wages £10 2s. 1d. (wage award pending) for a 44-hour week, less a deduction of £2 9s. 3d. for board and lodging (single quarters). The post is superannuable after two years service. —Applications in writing, stating age, previous experience and the names and addresses of two referees, should be addressed to the Superintendent Engineer, Royal National Orthopaedic Hospital, 234, Great Portland Street, London, W.1. E8072

ENGINEERING ASSISTANTS

(Civil, Mechanical and Electrical)

required by

METROPOLITAN WATER BOARD

Salary scale £625–£850 per annum (at present under review).
Commencing salary according to age and experience.
Permanent pensionable posts.

Applicants must have passed or be exempted from passing Sections A and B (or Parts I and II) of the examinations of the Institution of Civil Engineers, Mechanical Engineers or Electrical Engineers. Subject to certain conditions, promotion to the grade of Assistant Engineer (salary scale £885–£1090 per annum, which is also at present under review) is automatic upon obtaining Corporate Membership of one of these Institutions. There are opportunities for further promotion to higher grades.

HOUSING ACCOMMODATION MAY BE AVAILABLE AT A REASONABLE RENTAL.

Office hours 9 a.m. to 4.30 p.m. (Monday only 5 p.m.), Saturday (when on duty) 9 a.m. to 12 noon. Saturday morning leave increasing according to service.

Staff restaurant, sports clubs, &c.

Forms of application may be obtained from the undersigned, quoting reference (ENG.).

S. D. ASKEW,
Clerk of the Board.

Offices of the Board : New River Head, Rosebery Avenue, E.C.1. E8008

PUBLIC APPOINTMENTS

NIGERIAN RAILWAY CORPORATION

CHIEF ENGINEER'S OFFICE

PRINCIPAL TECHNICAL ASSISTANT

The Nigerian Railway Corporation invites applications for the following post :—

PRINCIPAL TECHNICAL ASSISTANT, salary £700 by £50 to £1100 p.a., plus £300 p.a. overseas pay.

The duties of the post will be to assist in the administration of the Chief Engineer's Office, including preparation of officers' duties rosters, draft indents, departmental instructions and dealing with technical reports.

Candidates should be at least 30 years of age and possess an Arts or Engineering Degree. They must have had at least 5 years' service in railway administration, with experience in programming new works and office organisation. Available on pensionable terms or on contract with 20 per cent gratuity per annum of total pay.

Tours : 15 months, followed by 15 weeks' leave in U.K. on full pay.

Allowances : in addition there are attractive allowances.

Apply to The London Representative, Nigerian Railway Corporation, 11, Manchester Square, London, W.1. E8073

TENDERS

COUNTY BOROUGH OF BRIGHTON

WATERWORKS DEPARTMENT

RESERVOIR LEVEL INDICATORS AND RECORDERS

TENDERS invited for SUPPLY, DELIVERY and SETTING TO WORK of ELECTRO-MECHANICAL EQUIPMENT for REMOTE INDICATION and RECORD of WATER LEVEL at THREE RESERVOIRS.

Conditions of Contract, Specification and Form of Tender obtainable from Waterworks Engineer, 12, Bond Street, Brighton. Deposit of £2 2s. will be refunded on receipt of bona fide Tender and return of documents supplied.

Tenders enclosed in plain sealed envelope not bearing any name or mark indicating the sender and endorsed "Tender for Reservoir Level Recorders" to be delivered to me before Saturday, 14th September, 1957.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. O. DODD,
Town Clerk.

Town Hall,
Brighton.
16th August, 1957. E8068

INDIA STORE DEPARTMENT

FERRO CHROMIUM

The Director General of India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :

	Quantity, tons
FERRO CHROMIUM : Chromium 60 per cent, Carbon 2 per cent max.	25

Forms of Tender may be obtained from the above address on or after 23rd August, 1957, at a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made payable to "High Commissioner for India." Tenders are to be delivered by 2 p.m. on Thursday, 3rd October, 1957.

Please quote reference No. 45/57/RLY. E8019

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guaranteed Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 E

FREE ! Brochure giving details of Courses in Mechanical and Production Engineering, Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other Professional examinations. —E.M.I. Institutes, Dept. E30, London, W.4. (Associated with H.M.V.) E972 E

WORK STUDY.—Part-time (evenings) 20 weeks' Diploma Course starts September 9th. Enrolments open now.—Details of this and five other courses, including full-time (six weeks) and correspondence, from School of Time and Motion Study, 29, Cork Street, W.1. Regent 0516. E7617 E

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN

(Dept. 76),
29, WRIGHT'S LANE, LONDON, W.8.
E102 E

EDUCATIONAL

UNIVERSITY OF MANCHESTER

The next Session commences on Thursday, 3rd October, 1957. E7704 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

A DESIGNER is required by the Trinidad Oil Company Limited to Administer and Instruct a Section of its Drawing-Office in Trinidad, British West Indies. Applicants should be Graduates in Civil Engineering of a British University, or else Associate Members of the Institution of Civil Engineers or of Structural Engineers. They should have not less than five years' experience in the design of load-bearing structures in both steel and reinforced concrete, including the design of foundations for such structures. Familiarity with soil mechanics is essential, and a knowledge of harbour works and land reclamation very desirable. Starting salary will be not less than £1500 per annum.

Please apply with brief particulars to the Personnel Officer, Trinoil (U.K.) Limited, Trinidad House, Old Burlington Street, London, W.1. E8009 A

A LARGE AND PROGRESSIVE Engineering Company in West Middlesex requires the services of four well-qualified DESIGNERS for work on light mechanical and electro-mechanical precision equipment and instruments. Candidates must have had a good general education, have served an engineering apprenticeship, have acquired the Higher National Certificate or its equivalent as a minimum qualification, and possess sound workshop knowledge as a background to their experience in the field of mechanical design work. They should be between the ages of 26 and 40 years and have the ability to work from schematic sketches and produce complete drawings for prototype construction. The appointments offer considerable scope to first-class men and a salary according to experience and qualifications of £800 to £1000 per annum is offered. Applications, in confidence, quoting full details of education and experience, should be addressed to "Designer."—BOX No. E8018, "The Engineer." A

A MECHANICAL ENGINEERING DRAUGHTSMAN is required by The Bahrain Petroleum Co., Ltd., 25 to 30 years of age, with minimum qualifications O.N.C. in Mechanical Engineering. Must have had at least 3 years' experience since completion of training in such work as production of original working drawings and field sketches of site alterations obtained in the drawing-office of a consultant, process design firm or jobbing maintenance organisation. The commencing salary is £1104 per annum, in addition to which free air-conditioned accommodation and local living allowance, medical attention and kit allowance are provided, with paid local and home leaves and participation in pension and provident fund plans.—Apply, in writing, quoting "ENG," with full particulars, to Caltex Services, Limited, Caltex House, Knightsbridge Green, London, S.W.1. E7984 A

A UNIQUE OPPORTUNITY has arisen for an ENGINEER to undertake research and development work on the cold forming of a range of steel components which have not previously been manufactured in this way. The position offers considerable prospects to a graduate (or equivalent) who is capable of original work and is interested in fundamental and applied research. The work will be undertaken in a new building of modern construction and in pleasant surroundings. Good pension scheme and other facilities. Apply in confidence giving details of qualifications, experience and present salary.—BOX No. E8035, "The Engineer." A

W. H. ALLEN SONS AND CO., LTD., require

(1) WORK STUDY ENGINEER, to establish a work study section at their Pershore Works. Candidates should have a sound engineering training with experience in deriving synthetic times for costing and incentive schemes.

(2) JIG AND TOOL DRAUGHTSMAN for Pershore Works, with sound engineering training and wide experience in Methods and Jig and Tool design.

Good conditions of employment with contributory pension and life assurance scheme.

Write in confidence, stating experience and qualifications, to : The Personnel Manager, Atlas Works, Pershore. E7955 A

A VACANCY EXISTS for GRADUATE MECHANICAL ENGINEER in the Development Department of Smiths Motor Accessories, Ltd. The successful applicant will be a man who get things done. His background must include an apprenticeship or practical experience, drawing-office and design experience, and at least five years' development experience with light precision engineering.—Apply to Mr. D. H. Squire, Cricklewood Works, N.W.2 (GLA 3333). E7989 A

SITUATIONS VACANT

ALLENS OF BEDFORD
have a vacancy in
THE DEPARTMENT OF THE WORKS ENGINEER
for

an ASSISTANT, who would be responsible to the Works Engineer for the design and maintenance of buildings and plant. Candidates should have a good technical training, H.N.C. or equivalent qualification. Good all-round practical experience is desirable. Up-to-date experience with the design of modern industrial buildings essential.

This post is interesting and will involve increasing responsibility.

Generous pension scheme ; assistance towards moving expenses.

Apply, stating age, and full details of experience to the Personnel Manager, W. H. Allen, Sons and Co., Ltd., Queens Engineering Works, Bedford. E8052 A

APPLICATIONS ARE INVITED by a well-established Mechanical Engineering Company in the East End of London, for a post which requires initiative, integrity and selling ability, coupled with a mechanical and technical training. Able to interview at all levels and discuss projects in machine production, fabricated steel vessels and machine parts. Car provided. Reply, giving full particulars and salary required.—BOX No. E1156, "The Engineer." A

ASSISTANT RESIDENT ENGINEER required for mechanical and plant erection work on new oil refinery and chemical plant constructions. Applicants, aged up to 40, should have had some experience in use of heavy lifting equipment, pipelines, &c., and control of labour. Commencing salary up to £1250 p.a., with normal benefits of a well-established and stable organisation. Please send full details in confidence.—BOX No. E8040, "The Engineer." A

ASSISTANT TO TECHNICAL ENGINEER. Age 21/25. Must have some drawing-office experience. O.N.C. in Mechanical Engineering desirable. Knowledge of hydraulics and/or automotive engineering an advantage.—Apply in writing, with full particulars and salary expected, to Secretary, E. P. Barrus, Ltd., 12–16, Brunel Road, London, W.3. E1152 A

ASSISTANT ENGINEER FOR DESIGN AND DEVELOPMENT

The Stanton Ironworks Company, Limited, Near Nottingham, require an ASSISTANT ENGINEER for design and development for work involving both civil and mechanical engineering. This is in connection with the design and development of an interesting range of precast concrete products, both reinforced and prestressed, and the associated plant layouts, &c. Applicants should hold an Engineering Degree or similar qualification. The post is a permanent one and offers good opportunity for promotion. There is a pension scheme.—Write, in confidence, to the Secretary, The Stanton Ironworks Company, Limited, Near Nottingham. E8031 A

ASSISTANT ENGINEERS are required in the Engineering Department of our Liverpool factory. The work is concerned mainly with mechanical engineering but extends to electrical and civil engineering. This is a good opportunity for a young engineer interested in gaining experience in the installation and maintenance of plant. Applicants should be under 35 years of age, and hold a Degree in Engineering or its equivalent ; men with a Higher National Certificate and industrial experience will be considered.—Application form obtainable from Personnel Manager, J. Bibby and Sons, Ltd., 57, Great Howard Street, Liverpool, 3. Please quote reference E.28. E7965 A

ASSISTANT WORKS MANAGER required by Manufacturing Light Engineers and Instrument Makers. Excellent forward prospects. Age group 30–35. Must be well-experienced in machine shop management and production control. West of London area.—Ref. P/GM., BOX No. E7999, "The Engineer." A

BRITISH PETROLEUM COMPANY has vacancy for an ENGINEER for service overseas. Applicants, aged 23–30, must have O.N.C. or Second Class M.O.T. (Motor) Certificate, and have served an engineering apprenticeship with a firm engaged in the erection and testing of diesel engines. Minimum of two years' subsequent experience in the operation and/or repair of diesel engines either as sea-going engineer, power-house shift operator or with a reputable firm of engine builders engaged on engine installation and test work. Salary according to age, qualifications and experience, non-contributory pension scheme, kit allowance.—Write, giving full particulars, quoting H.4071, to BOX 5397, c/o 191, Gresham House, E.C.2. E8043 A

CHIEF DESIGNER required by well-established manufacturers of range of food machinery, Eastern Counties. Applications stating age, full details of past experience, and salary required are invited.—BOX No. E1158, "The Engineer." A

CHIEF ENGINEER required for Chemical Factory in Kent. Capable of maintenance of existing equipment and erection and fabrication of new plant. Please state salary required.—BOX No. E1130, "The Engineer." A

CHIEF ESTIMATOR AND ESTIMATOR

Applications are invited by engineering concern (Tyneside area) for the position of Chief Estimator. Applicants should have general engineering production experience and the ability to estimate rapidly and accurately from drawings, specifications and layouts.

A further opening is available for an Estimator, who must have wide experience of engineering workshop practice, and be able to estimate from layouts and specifications.

Please write, stating age, previous experience, past employers, salary, &c., to BOX No. E8069, "The Engineer." A

CHIEF ROLL DESIGNER, aged 35–45, required by large steel works. Applicants should be fully conversant with the designing of rolls for heavy and light mills, rolling rounds, billets, channels, angles, tees, &c., in a wide range of sizes. The position carries excellent prospects and a good salary will be paid to the right man. A pension scheme and free life assurance scheme are in operation. Write, giving full details of age, qualifications and previous experience.—BOX No. E7910, "The Engineer." A

CIVIL ENGINEERING DESIGNERS required by Westminster consulting engineers with experience in the design of one or more of the following : harbour and dock works, bridges, large dams, reinforced concrete and mass concrete structures. Salary according to experience. Five-day week, pension scheme, luncheon vouchers. Apply, stating age and experience.—BOX No. E7888, "The Engineer." A

CLARKE, CHAPMAN AND CO., LTD., invite applicants for the following : MECHANICAL DRAUGHTSMEN. Preference given to men with some experience of boiler-firing equipment, but this is not essential. Pension scheme in operation and five-day week. First-class opportunities for advancement.—State age, experience, qualifications and salary required, Personnel Officer, Clarke, Chapman and Co., Ltd., Victoria Works, Gateshead, 8. E8002 A

CLARNICO LIMITED have a vacancy for a DEVELOPMENT ENGINEER. Applicants should be educated to at least H.N.C. level and have drawing-office experience. The work includes preparation and improvement of production layouts, design of improved production methods and mechanisation projects, &c. An ideal job for an engineering Graduate wishing to gain experience in the food industry.—Apply in writing to Personnel Manager, Clarnico, Ltd., Waterden Road, Stratford, E.15. E8025 A

CONSULTING ENGINEERS have a vacancy for CIVIL ENGINEER, experienced in the exploratory work for, and subsequent design and construction of, large hydro-electric projects involving the construction of large impounding dams. Applicants must be Chartered Civil Engineers not less than 35 years old and must have several years' experience in a leading capacity as senior engineer on the investigation and construction of such projects. Salary from £1800 p.a. to £3000 p.a., according to status and experience. Applications, which will be treated as strictly confidential—BOX No. E1133, "The Engineer." A

DESIGN DRAUGHTSMEN.—The British Drug Houses, Ltd., invite applications from suitably qualified men for interesting work in the Engineers Drawing Office, on special machines and plant layouts for the Light Chemical Industry. H.N.C. in Mech. Eng. and previous experience in this industry desirable but not essential. Men of mature age with suitable training and experience, would be considered. Five-day week, pension and profit-sharing schemes.—Write, stating age, experience and salary required, to Staff Manager, Graham Street, N.1. E7871 A

DESIGN DRAUGHTSMEN
(£750 p.a. to £1000 p.a.)
for General Arrangement and Detail Work, also for Gear Box and Engine Design Work, urgently required by Morris Motors Limited, Engines Branch, Coventry. Excellent conditions and prospects. Write (in confidence), giving age, experience and salary required, to Employment Manager at above address. E1151 A

DESIGNER-DRAUGHTSMAN, with experience water-tube boilers, required for newly formed company, south of London. Good prospects and salary. —BOX No. E1080, "The Engineer." A

DESIGNER-DRAUGHTSMEN, experienced in Jib Cranes &c. Position offered, due to expansion of firm's activities, would be permanent, progressive, and would carry salaries commensurate with experience. Pension scheme.—Apply : Chief Engineer, Clyde Crane and Engineering Co., Mossend, Nr. Motherwell. E7874 A

DESIGNER-DRAUGHTSMEN & DETAILERS wanted for work on chemical plant layout, vessel design and pipework, &c. Top salaries offered men with experience and maximum assistance in regard to housing. Grant towards removal expenses and living allowance until removal completed. Pension and insurance scheme, technical library, sports ground.—Apply, "ref. D," Staff Personnel Manager, Power Gas Corpn., Ltd., Stockton-on-Tees. E7738 A

DRAUGHTSMAN (Senior) having experience in machine design and works layouts. A knowledge of works building design desirable but not essential. Technical education to at least O.N.C. standard. DRAUGHTSMAN (Junior) for General Engineering Design or Jig and Tool Design.—Applicants are invited to submit full details of age, experience and salary required, to the Personnel Manager, Ferodo Limited, Chapel-en-le-Frith, Via Stockport. E7963 A

DRAUGHTSMAN, capable man for chemical engineers in London. Layout and detail. Pension and bonus schemes. Overtime payment. Particulars.—BOX No. E1161, "The Engineer." A

DRAUGHTSMEN AND PRESS TOOL DESIGNERS

Vickers-Armstrongs (Engineers), Limited, have vacancies in their Die Design Drawing-Office for men interested in the design of Press Tools for the production of Motor-car Body Panels.

Good prospects for suitable applicants.

Write, giving full details of age, experience and past record, to the Personnel Officer,

VICKERS-ARMSTRONGS (ENGINEERS), LIMITED,
Elswick Works,
Newcastle upon Tyne, 4.
E8058 A

DRAUGHTSMEN required in the following categories : Senior and Junior Piping and Instrumentation ; Senior and Junior Reinforced Concrete ; Senior Mechanical, by engineers in City engaged on nuclear, petroleum, chemical plants. H.N.C./O.N.C. desirable. Salaries above average, five-day week, pension/life assurance and personal accident schemes, house purchase assistance, luncheon vouchers.—Write full particulars to Head Wrightson Processes, Ltd., 24/26, Baltic Street, E.C.1. E954 A

ELECTRICAL DESIGNER sought by established manufacturers, in London, with world market for special-purpose precision machinery. Exceptional prospects for qualified electrical engineer having practical experience, aged 30-40, who is possessed of the "creative spark." Only applicant fertile in ideas, with original and inventive mind and receiving recognition in his present post on this account, need apply.—Write in confidence, Personnel Manager, Molins Machine Co., Ltd., Evelyn Street, London, S.E.8. E7882 A

ELECTRICAL/MECHANICAL ENGINEERING DESIGNER

This senior position with Merseyside company of medium size calls for rotating machine design ability, both electrical and mechanical, of a high order. Experience on control gear and systems, including electronics, is equally desirable.

The company, associated with a large group, expects to pay an attractive four-figure salary to a top-flight Designer who is looking for a challenging position in which he can both develop and extend the company's existing range of products. These products are of small/medium size and special-purpose type.

First-class qualifications are necessary ; adequate benefits are available. Applications, which should include age and salary indication, will be treated most confidentially.—BOX No. E7920, "The Engineer." A

ELECTRICAL ENGINEERS, with B.A. or B.Sc. Degree, required for work in connection with nuclear power stations by well-known consulting engineers in London. Applicants should have previous experience in the design and/or operation of large rating electrical plant, alternators and motors. Applications, in the candidate's own handwriting, giving full details of education, qualifications and previous experience. —BOX No. E8047, "The Engineer." A

Classified Advts. continued on page 6

BOOKS and PUBLICATIONS

REGIME BEHAVIOUR of CANALS and RIVERS

By Professor T. BLENCH, B.Sc., M.I.C.E., M.A.S.C.E.
University of Alberta. 30s.

The aim of this book is to give the practising engineer the means to solve, with practical quantitative accuracy, problems arising from work with canals and rivers which form their boundaries from sediment and so will not submit to arbitrary interference.

The development is logical, in terms of formulas of dynamically satisfactory form discovered by observing the natural self-adjustment of canals designed arbitrarily but allowed to adjust to natural dimensions eventually. Major practical problems are illustrated by worked examples.

A special chapter discusses fundamental dynamics for specially interested or expert readers, and an appendix gives practical data and the location of all formulas.

It will also form a useful University textbook on mobile hydraulics and its applications to rivers and canal engineering.

Descriptive leaflets, listing full contents, available from :

Butterworths Scientific Publications
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KEMPE'S

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SITUATIONS VACANT

ENGINEER, aged 22 to 30, electrical or electronic, preferably university trained, required by Liverpool consultants for training in a most exclusive and under-populated profession. Excellent salary and prospects and congenial conditions of employment. State experience and present salary.—BOX No. E1163, "The Engineer." A

ENGINEER, aged 28–32 years, with Degree or Higher National Certificate, required to join team engaged on research into vibration of machine tools. A knowledge of electronics would be an advantage. Previous experience on vibration research not essential; suitable applicant will be trained. Send full details, including present salary, in confidence.—BOX No. E8051, "The Engineer." A

ENGINEERS are required to work on the design and development of production plant for the manufacture of brake and clutch linings. Duties require an ability to follow jobs through all stages of development until designed performance of production plant is obtained and operatives for the plant are trained. Applicants must hold at least H.N.C. in Mechanical Engineering or equivalent, and have had works and drawing-office training with good experience in general plant design.—Write, stating age, education, qualifications and salary required, to the Personnel Manager, Ferodo Limited, Chapel-en-le-Frith, Via Stockport. E8023 A

ENGINEERS

are required by Sperry, manufacturers of high precision instruments, for the following posts at Brentford and Feltham (Middlesex):

PRODUCTION DEVELOPMENT ENGINEER to advise on methods and design changes required in adapting experimental instrument designs for ease of manufacture. In addition to good knowledge of machine shop techniques, an acquaintance with design problems and an engineering qualification would be an advantage.

PRODUCTION ENGINEERS for:
(1) Small batch high precision machining.
(2) Assembly of precision equipments.

H.N.C. standard and good practical experience necessary.

Good salaries and prospects of advancement. Write, quoting Ref. E257, to the Personnel Manager,

Sperry Gyroscope Company Limited,
Great West Road, Brentford, Middlesex.
E8013 A

ENGINEERS with specialised training in the design and execution of prestressed concrete projects are required for permanent employment in Rhodesia and the Union of South Africa. Free passages, pension scheme, excellent prospects.—Full details to BOX JY/29, c/o 95, Bishopsgate, London, E.C.2. E973 A

ENGINEER/DRAUGHTSMAN required for Mechanical Plant Development.—Application, giving details of qualifications and experience, should be addressed to Personnel Manager, Holland & Hannen and Cubitts, Ltd., 1, Queen Anne's Gate, London, S.W.1. E8015 A

ENGINEER-DRAUGHTSMAN. Senior for chemical plant layout and detail. Near Waterloo. Site experience an advantage. Excellent salary, pension and bonus schemes.—BOX No. E1162, "The Engineer." A

ENGINEERING.—A MAINTENANCE ENGINEER is required by a prominent manufacturing company in the Provinces for responsible duties in a new factory employing approximately 4000 people. The duties will include taking charge of installing new plant and the carrying out of modernisations. Broadly, candidates must have had sound experience in plant maintenance and some knowledge of the operation of incentive schemes would be an advantage. Preference will be given to those with a University Degree and Graduates or Associates of the Institution of Mechanical Engineers. The starting salary will be not less than £1000 per annum and may be more for a man with particularly appropriate experience and ability. Please reply, giving full particulars.—BOX No. E8054, "The Engineer." A

ENGINEERING EXECUTIVE

Applications are invited for position of Senior Assistant to Engineering Director and Works Manager of large Engineering Works (Marine). Applicants, who must be British born Nationals, should give full particulars of training, qualifications, experience and age. Preference will be given to applicants who have held positions of responsibility for at least five years.—BOX No. E7997, "The Engineer." A

ENGINEERING INSURANCE COMPANY has vacancy on its Engineering Staff in Manchester for a qualified ENGINEER experienced in crane design. Age 30–35. Progressive salary. Non-contributory pension and other benefits.—BOX No. E8001, "The Engineer." A

ENGINEERING INSURANCE COMPANY invites applications from Engineers not over 35 years of age who possess First Class M.O.T. Certificate (Steam) for position as ENGINEER SURVEYOR in London and surrounding districts. Progressive salary scale rising to over £1000 per annum plus expenses and allowances. Non-contributory pension scheme and other staff schemes. Apply in own handwriting.—BOX No. E7903, "The Engineer." A

ENGINEERING SALES MANAGER.—Exceptional opportunity with London concern having interests in every branch of engineering and science. Sound, practical and technical training, experience in sales promotion and management and ability to organise, are essential. Attractive salary and conditions. Age 30–50.—BOX No. E7923, "The Engineer." A

ENGINEER REPRESENTATIVE, basic mechanical engineering background and commercial experience desirable. High and low-pressure pipework fabrication and installation, medium heavy forgings, required for North-West area, with occasional visits to Midlands. Applicant would be required to be based in Manchester area. State age, experience and salary required.—BOX No. E1142, "The Engineer." A

EXCELLENT POSITION for WELDER with personality, up to City and Guilds or Institute of Welding standard. Training for specialised work which will consist of some demonstration, tuition of welders, with possibility of foreign travel. Applicant should be prepared to take responsibility as extension of service into department expected. Reply, stating full particulars, including age and salary required.—BOX No. E1168, "The Engineer." A

FOREMAN PLATELAYER required for laying new and maintaining existing railway track at large steel works in the Midlands. Staff position, pension scheme, free life assurance, &c. Write, giving details of age and experience.—BOX No. E7908, "The Engineer." A

G.E.C.–SIMON-CARVES ATOMIC ENERGY GROUP
have vacancies for
ENGINEERS

interested in theoretical or experimental structural and stress analysis for design and development work on reactor pressure vessels and complex steel structures.

Previous experience is desirable but not essential.

These posts offer excellent opportunities for imaginative young men under 28 years of age who are anxious to join a rapidly expanding organisation in a new and important branch of engineering. The positions are suitable for University Graduates with or without an Honours Degree and in some cases for candidates with a National Certificate.

Apply, giving age and particulars of training and experience, to Personnel Manager (K.J.W.), The General Electric Company Limited, Fraser and Chalmers Engineering Works, Erith, Kent. E7960 A

GENERAL SUPERINTENDENT (European), required for large well-established British-owned factory in Calcutta manufacturing a wide range of electric motors, transformers, switchgear, &c. Must have had considerable experience in charge of shops producing similar equipment. Knowledge of latest manufacturing methods and processes, and ability to organise operations for fast and economical production essential. The man appointed will be required to plan and install an efficient piecework system in the factory where only day-work has been in operation up to the present, and good experience of the introduction and operation of piecework systems is essential. Age 30-40. Salary before tax including dearness allowance 3,300 rupees per month, plus travelling expenses, free passage to India including wife and family, free accommodation and medical attention. Appointment will be subject to a three-year renewable contract.—Reply with names of references to Secretary, A.E.I. Overseas, Ltd., Crown House, Aldwych, London, W.C.2. All applications will be treated in confidence. E1160 A

GLACIER METAL CO., LTD., KILMARNOCK, AYRSHIRE
ENGINEERING MANAGER

A qualified and experienced SENIOR PRODUCTION ENGINEER is required to control and develop the full range of production engineering activities in a factory production unit.

He and his staff will be responsible for the continual review and improvement of production methods, the preparation of estimates and manufacturing layouts, the design and ordering of job tooling, and the establishment of targets and time standards for production.

The ideal applicant will be someone who has an Engineering Degree and/or membership of either the Institution of Mechanical Engineers or the Institution of Production Engineers; a wide experience of production engineering, including development work, tool design, trouble shooting and some knowledge of estimating and planning routines.

The factory is a modern one situated close to the Ayrshire coast and a generous salary and excellent prospects for further advancement are offered to the successful applicant.

Applications, containing details of qualifications, experience and present salary, should be sent to Personnel Manager, The Glacier Metal Co., Ltd., Kilmarnock. E8059 A

GROWING CONCERN iron and steel distributors, also sub-contractors for structural work, offer opportunity to YOUNG MAN with some knowledge in this field. Good prospects for right man.—BOX No. E1171, "The Engineer." A

JACKSON BROS. (OF KNOTTINGLEY), LTD., require ENGINEERING ASSISTANTS for maintenance and development work in a modern Glass Container Works. The posts are permanent and pensionable, and offer scope for further training and advancement. Previous experience in glass-works not essential. Successful applicants must have served an engineering apprenticeship, must be either A.Grad.I.Mech.E., or studying for this qualification, and have had some experience in general works maintenance. Experience in modern machine shop practice is an advantage. Salary will be according to qualifications and experience.—Applications to the Personnel Officer, Messrs. Jackson Bros. of Knottingley, Ltd., P.O. Box No. 2. E1136 A

MACHINE SHOP SUPERINTENDENT required by large British-owned Electrical Engineering Company's manufacturing plant in India. Applicants should be between ages of 30 and 40 years and have served a machine shop craft apprenticeship with subsequent experience in machining medium-sized products on batch production. Applicants should have risen to foreman or potential foreman status and be able to demonstrate machine tools and train labour. Experience of blanking presses, electroplating and light non-ferrous casting desirable but not essential. The appointment is a senior one, would be for 3 years in the first instance, with passage accommodation, medical expenses for self and family provided free. The gross salary before tax would be in the range of 1800 and 2250 rupees per month, depending on age and experience. The appointment is pensionable.—Full details should be sent to the Secretary, A.E.I. Overseas, Ltd., Crown House, Aldwych, London, W.C.2. E1153 A

LARGE ENGINEERING GROUP requires outstanding young man to assist in the technical development and management of one of its subsidiaries in the Manchester district. The successful applicant will be assistant to the managing and technical directors. Knowledge of paper making and converting machinery an advantage but not essential. The position is in the salary range of £2000 per annum according to experience and qualifications.—Applicants must submit full details of age, education, qualifications, experience and salary required to BOX No. 506, Dorland Advertising, Ltd., 18-20, Regent Street, S.W.1. E8034 A

MANAGER REQUIRED FOR LARGE CENTRAL WORKSHOPS

A manager with engineering qualifications and a capacity for leadership is required by the West Midlands Divisional Coal Board for the central workshops of their North Staffordshire area. Salary will be within the range £1000 to £1600.

The workshops, located at Hem Heath Colliery, Trentham, Stoke-on-Trent, will employ between 200 and 300 men when fully manned. They will serve all the collieries in the area. Reconditioning of mining machinery and fabrication of a certain amount of new equipment will be their main functions.

The post is one which requires a man who has had appropriate experience, including service as a senior executive either in a workshop of similar type or in a general engineering workshop.

Evidence will be required of the successful application of modern production, planning and industrial managerial organisational methods in all their aspects.

Minimum technical qualification required is a Higher National Certificate in either Mechanical or Electrical Engineering, or equivalent. Membership of an appropriate recognised professional body will be an advantage.

Detailed applications should be sent to the Area Staff Manager, West Midlands Divisional Coal Board, 72, Leek Road, Stoke-on-Trent, by August 31, 1957. E8028 A

MANAGEMENT SELECTION, LIMITED,

have been retained to advise on the appointment of a

WORKS MANAGER

for a young company (50 employees) in the North-East, which is a subsidiary of a well-established Canadian organisation specialising in drilling equipment. At present the company is mainly concerned with the U.K. market, but the future programme involves extension of its activities throughout the sterling area.

The Works Manager will be responsible to the Managing Director for all aspects of manufacture, production control, stores and maintenance, and will be expected to take an active interest in the future development plans.

Candidates must have attained a position of responsibility, preferably as production or works manager, and have experience of modern machine shop practice and production control methods. A degree or other professional qualification in mechanical engineering essential. There is a non-contributory pension and insurance scheme and the company is prepared to assist with removal expenses, if required.

Preferred age 35–40. Salary not less than £2000.

Please send brief details in confidence, quoting reference G.494, to M. B. Berks, Management Selection, Limited, 17, Stratton Street, London, W.1. No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. E8057 A

MECHANICAL ENGINEER required by Smiths Motor Accessories, Ltd., H.N.C. standard and at least 5 years' practical experience in light engineering, preferably instrument testing.—Apply to Mr. D. H. Squire, Cricklewood Works, N.W.2 (GLA 3333). E7990 A

MECHANICAL ENGINEERING DRAUGHTSMAN required for interesting work in a Civil Engineering Plant Office. Age 21–25 years.—Applications, stating education, technical qualifications, experience, salary required, and age, should be sent to: WEST'S PILING AND CONSTRUCTION CO., LTD., Bath Road, Harmondsworth, West Drayton, Middlesex (opposite London Airport). E8000 A

MECHANICAL ENGINEERS, with B.A. or B.Sc. Degree, required for work in connection with nuclear power stations, by well-known consulting Engineers in London. Applicants should have previous experience of the design and/or operation of steam turbines, pumps, high-pressure steam and feed ranges, feed heating systems and pumps, and circulating water systems and plant, and compressor plants. Applications, stating in detail age, education and previous experience, in candidate's own writing.—BOX No. E8048, "The Engineer." A

MECHANICAL ENGINEERS.—Progressive and expanding industrial organisation situated in a pleasant area in the South of England requires Mechanical Engineers for the design, construction and maintenance of plant and equipment for the production and processing of synthetic resins. Excellent opportunity for men with adequate qualifications, energy and initiative to progress to positions of responsibility in a managerial capacity. Starting salaries up to £1200 per annum. Profit-sharing, pension fund. Assistance in house purchase, facilities being available in approved cases for substantial loans. Lodging allowance for a period not exceeding six months at the rate of £260 per annum to married men whilst maintaining two homes. Refund of removal expenses incurred in removing to the new place of work of up to £50. Apply in writing.—BOX No. E7996, "The Engineer." A

MECHANICAL LAYOUT DRAUGHTSMEN, possessing Higher National Certificate or equivalent qualifications, required by well-known consulting engineers in London for work on nuclear power stations. Applicants should have previous experience in the layout of power station plant, high and low-pressure pumps and pipework and turbine-house and circulating water auxiliary plant. Applications, in the candidate's own handwriting, giving full details of education and subsequent training and experience.—BOX No. E8049, "The Engineer." A

MOXEY, LIMITED, have vacancies for PROJECT ENGINEERING DRAUGHTSMEN in their Birmingham office, bulk handling or good structural experience essential. Bonus and pension schemes and canteen facilities.—Apply, 13, Augustus Road, Edgbaston, Birmingham, 15. E1166 A

POWER-HOUSE SUPERINTENDENT required by the Baghdad Electricity Services for steam power station, medium pressure, 41MW installed capacity, Babcock boilers and Parsons turbo-alternators. Three years' initial contract, three months' leave after twenty-four months in Iraq. First-class passage paid for successful applicant and family. Salary Iraqi Dinars 170 per month, plus high cost-of-living allowance ID.22 to 25, according to number in family. Free house and heavy furniture provided. Age 35 to 45 years. Provident fund exists.—BOX No. E7991, "The Engineer." A

PROJECT ENGINEERS (ELECTRONIC AND MECHANICAL, INCLUDING INDUSTRIAL PHYSICISTS)

Nash and Thompson require a Senior and Junior Project Engineer for electronic instrument development, also a Senior and Junior Engineer experienced in development of precision mechanical and hydraulic units.

We are sure that the wide and varied range of work in our laboratories will be of absorbing interest to the enthusiast in an organisation not large enough to cause frustration.

Apply, giving complete details of education, experience and salary required, to the Director and General Manager, Nash and Thompson, Ltd., Oakcroft Road, Chessington (off Kingston By-Pass), Surrey. E8056 A

ROWNTREE AND CO., LTD., require an ENGINEER for their engineering research department at York. This post will be concerned with the design, development and installation of automatic machinery for packing, wrapping and box making. Applicants must have a good technical education, University Degree preferred, and some experience in the design of automatic machinery.—Intending applicants are requested to write in confidence for official application form to the Staff Officer (Men) (ref. R.W.R.), Rowntree and Co., Ltd., The Cocoa Works, York. E8071 A

SALES REPRESENTATIVES (two) for S.E. England and N. England required by old established company manufacturing extensive new range of drying and allied machinery. Applicants should have engineering background, preferably with experience and connections in the chemical and food industries.—BOX No. E1159, "The Engineer." A

SENIOR DRAUGHTSMAN required for steel works in the Midlands area. Experience in steel works practice desirable but not essential. Good conditions and prospects and permanent situation offered to suitable applicant. Pension scheme and free life assurance scheme and canteen facilities. Excellent salary range. Apply, giving age and experience.—BOX No. E7907, "The Engineer." A

SENIOR SHIPBUILDING DRAUGHTSMAN AND MECHANICAL DRAUGHTSMAN VACANCIES

Applications are invited from suitably qualified Draughtsmen for the above vacancies.

Applicants for the position of Senior Shipbuilding Draughtsman must be approximately 40 years of age or more and have had considerable experience in small ship design and conversion. Preference will be given to applicants having experience of dredging equipment, bucket dredgers, cutter suction dredgers, trailers, self-propelled hoppers, &c. The successful applicant will be required to supervise a small drawing-office staff and he must be prepared to take full responsibility. A generous salary will be paid to the right man and the position will be pensionable on a non-contributory basis after a probationary period of one year.

Applicants for the position of Mechanical Draughtsman should also preferably be experienced in dredging machinery, but must, in any event, be thoroughly experienced in the design, &c., of ships' machinery. They should not be less than 35 years of age. This position will become pensionable after four years' service.

Assistance will be given towards housing in both cases, in the form of a loan repayable without interest.

When applying, applicants for both positions must give the following information in writing:
(a) Age, nationality and whether married or single.
(b) Full details of career to date with positions and degree of responsibility held.
(c) Technical qualifications.
(d) Names of responsible persons to whom reference may be made concerning character and technical ability.
(e) Present salary and salary required if application is successful.
(f) When available to take up new employment.

It is emphasised that only persons who are of proved ability and who have already held responsible positions need apply.

Westminster Dredging Company, Ltd.,
301, New Chester Road,
Bromborough,
Wirral, Cheshire. E1155 A

SENIOR MECHANICAL DESIGN DRAUGHTSMEN are invited to join a progressive design team engaged on varied and interesting work in the compressed air industry.—Write, or 'phone, details of experience, salary required, &c., to the Chief Draughtsman, Air Pumps, Ltd., Bushey Road, London, S.W.20 (WIMbledon 9441). E7929 A

SITUATIONS VACANT

SENIOR PLANT ENGINEER, aged 35/45 (A.M.I.Chem.E., or A.M.I.Mech.E.) for interesting progressive position at large Chemical Works in Stratford, E.15.—Write full details age, qualifications, experience and salary desired, to Staff Manager (Ref. S.), F. W. Berk and Co., Ltd., Commonwealth House, 1–19, New Oxford Street, W.C.1. E8017 A

SENIOR TECHNICAL SALES ENGINEERS required, to introduce and sell fluid power transmission equipment to those manufacturers who make and want the best. Applicants should have Matriculation standard, have good engineering background, possess intimate knowledge of mechanical processes combined with electrical drives and transmissions; age approx. 40. Give full details of education, qualifications and experience, stating branch of industries and firms concerned, present salary.—BOX No. E1167, "The Engineer." A

STEEL WORKS ASSISTANT ENGINEER required by a large Midlands steel works to supervise the maintenance of a modern open-hearth melting shop and associated waste heat boiler installation. Applicants should be of Higher National Certificate standard or equivalent and have experience of modern steel works maintenance. This is a staff position with a pension scheme and free life assurance. Write, giving full details of age, experience and remunerations required.—BOX No. E7909, "The Engineer."

TECHNICAL SALESMAN

wanted for large engineering works in West London, dealing with extensive range of new and reconditioned hydraulic and rubber machinery. A commencing salary of £1100 p.a. is offered, and there are good prospects of advancement. Preference will be given to applicants with works and drawing-office experience. Contributory pension scheme. Apply, stating age, experience and qualifications—BOX E8076, "The Engineer." A

TECHNICAL / SALES REPRESENTATIVE wanted to cover East, Mid and South Scotland, resident preferably Glasgow–Stirling–Edinburgh area. To represent small firm of manufacturer/distributors of complete undergear equipment for all types of trailed vehicles, machinery, mobile equipment, &c. Some knowledge of engineering required. Applicants should write, stating experience and remuneration required.—BOX No. E1165, "The Engineer."

THE CHESTERFIELD TUBE COMPANY require DESIGNER-DRAUGHTSMEN, preferably experienced in medium and heavy engineering handling equipment. Excellent opportunities and scope for the right men. Salary according to qualifications and experience, permanent position, five-day week, contributory pension scheme, canteen facilities, &c.—Apply, stating age, details of past experience and salary required, to Personnel and Welfare Department, Derby Road, Chesterfield. E8041 A

THE CHESTERFIELD TUBE COMPANY wish to appoint a CHIEF DESIGNER to manage their Development Drawing-Office, having a staff of about seventeen. Applicants who should have experience in medium to heavy mechanical engineering, will find ample scope for initiative and imagination in the development of special plant of a highly mechanised type. A substantial salary will be paid to the right man. Permanent position, five-day week, pension scheme and canteen facilities.—Apply, stating age, details of past experience and salary required, to Personnel and Welfare Department, Derby Road, Chesterfield. E8007 A

THE DISTILLERS COMPANY LIMITED

The company has a vacancy at the South Wales factory of its subsidiary, British Resin Products Limited, for a technically qualified man to occupy a responsible position in a laboratory being established to provide Technical Service for a new thermoplastic material. The factory is situated in pleasant semi-rural surroundings near Cardiff. Applicants should be aged between 25 and 35, and should preferably hold a Degree, or equivalent qualification, in Chemistry, Physics or Engineering; good experience of the plastics industry is essential, whilst experience of plastics fabricating equipment (e.g. injection machines, extruders) is desirable. Salary according to qualifications and experience. Non-contributory pension scheme.—Write: Staff Manager, The Distillers Company Limited, 21, St. James's Square, London, S.W.1. Quote Ref. 45/57. E8014 A

WORKS ENGINEER

(with prospects of a Board appointment)

An important company in the North of England concerned with manufacture in the woodworking industry, invites applications from qualified mechanical engineers for the appointment of a Works Engineer, to be responsible to the Managing Director for all engineering, other than production, and would be required to manage and co-ordinate the services, maintenance and other engineering functions of the company.

Previous experience in the woodworking industry would be an advantage, but it is not essential. Qualifications should include A.M.I. Mech.E., and good general mechanical experience with evidence of organisation and managerial ability.

Age range 33/50. Salary £2000–£3000 (approx.)

Full particulars, stating age, qualifications, experience and degree of responsibility, to:

The Secretary,
THE PROFESSIONAL ENGINEERS APPOINTMENTS BUREAU,
9, Victoria Street,
London, S.W.1. E7979 A

WELL QUALIFIED young ENGINEER, trained in electrical engineering or electronics, required by large firm of chartered patent agents in Northern England. Excellent prospects. State present salary and details of training.—BOX No. E1164, "The Engineer." A

TRANSFORMER DEPT. SUPERINTENDENT required by large British-owned Electrical Engineering Company's manufacturing plant in India. Applicants should be between the ages of 30 and 40 years and have served an electrical engineering craft apprenticeship with subsequent experience of all aspects of the manufacture of distribution and power transformers in the range of 50kVA. to 2500kVA. and up to 33kV. Applicants must be thoroughly conversant with modern methods and have reached at least the position of foreman on similar work, and be able to demonstrate and train labour. The appointment is a senior one, would be for 3 years in the first instance, with passage accommodation, medical expenses for self and family provided free. The gross salary before tax would be in the range of 1800 to 2250 rupees per month, including cost-of-living allowance, depending on age and experience. The appointment is pensionable.—Full details should be sent to the Secretary, A.E.I. Overseas, Ltd., Crown House, Aldwych, London, W.C.2. E1154 A

WELDING ENGINEERS required in London office for preparation of welding procedure specifications for alloy materials, and for liaison with drawing and design offices and sub-contractors on welding problems. Also for works at Egham, Surrey, to revise procedure specifications in accordance with actual welding practice and procedure tests, and to assist in development of new welding techniques and application of new welding machines. Experience of Class 1 welding of heavy pressure vessels or high pressure pipework is essential. Technical qualifications Higher National Certificate or equivalent.—Write stating age and experience: Foster Wheeler, Limited, 3, Ixworth Place, S.W.3. E8030 A

STEELWORKS MECHANICAL ENGINEER FOR INDIA

Mechanical Engineer, with overall experience of Steelworks Plant who wishes to save 50 per cent of his salary over the next three years, is required to supervise the erection and commissioning of a large integrated Steel Plant being erected in India. Conditions of employment are good and the location is healthy. Good salary and allowances are paid to an experienced man, who should be over 35 years of age.—Applications, stating age, education, experience and whether married or single, should be made to BOX No. E8036, "The Engineer." A

SENIOR DRAUGHTSMAN

required, experienced in heavy machinery plant layout and material handling; first-class man only.

This is an opportunity to join small team in large organisation, offering regular employment with good salary, pension fund and profit-sharing bonus.

Reply, giving full particulars of experience, age, &c., to

The Chief Engineer,
THE ASSOCIATED PORTLAND CEMENT MANUFACTURERS LTD.,
Portland House, Tothill Street, London, S.W.1
E7855 A

PAMETRADA RESEARCH STATION, WALLSEND

requires a

DEPUTY DIRECTOR (DESIGN)

The position is a very highly responsible one and offers very real scope for the development of marine turbine designs. Applicants should have a University Degree in Mechanical Engineering and have had wide experience in the design and manufacture of steam turbines operating under high inlet conditions, and also have held a responsible Design Office position. A knowledge of gas turbine design and construction is an additional advantage. Applicants should be aged between 35 and 45, although some departure at the upper end of the scale will be considered if all other requirements are satisfactory. The position is permanent and pensionable. The salary offered will be in the region of £3500 according to qualifications.—Applicants should send full particulars of qualifications, experience, &c., to the Director, Pametrada Research Station, Wallsend Northumberland. Replies will be treated in the strictest confidence. E7922 A

ESTIMATING ENGINEER

Applications are invited for an appointment in the Project Group of

BRITISH OXYGEN ENGINEERING LIMITED

The work involves estimating and tendering for plant components such as pressure vessels, scrubbers, pipework and machinery for handling gases, and good experience in this, or a related field of work, is necessary.

The Company offers excellent salaries and conditions of service and assistance with house purchase expenses will be given to people from outside the London Area.

Applications, giving details of experience, qualifications, age and salary required, should be sent to:

Personnel Manager, British Oxygen Engineering Limited, 160 Piccadilly, LONDON, W.1

E8016 A

Designers & Draughtsmen

MECHANICAL

Applications are invited from men with good experience of CHEMICAL PLANT DESIGN, including pressure vessels, heat exchangers, pipe work, pumps, etc., and/or GENERAL PLANT LAYOUT & INSTALLATIONS.

These are important posts in an interesting field of work, and are located at the Company's Offices in

CENTRAL & NORTH LONDON

Excellent conditions of service are offered including

ASSISTANCE WITH HOUSING

Local interviews can be arranged.

Applications in writing or by telephone giving full details of age, experience, qualifications and salary required should be made to:—

Staff Officer,
British Oxygen Engineering Ltd
Angel Road · Edmonton
LONDON, N.18
Tel: EDM 3020

E85 A

NUCLEAR POWER STATIONS

PRESSURE VESSEL ENGINEERS & DRAUGHTSMEN

Applications are invited for the following appointments in the

ATOMIC ENERGY DIVISION

of

The General Electric Company Limited

(1) PRESSURE VESSEL ENGINEERS

Applicants should have design experience on pressure vessels for the refinery or chemical industries and should be conversant with the various codes of practice. Shop fabrication or site erection experience would be an advantage. Minimum qualifications H.N.C.

Duties would include the development of designs, from initial concept to fabrication stage, of the numerous pressure vessels which are required in this field for power stations and research projects. Some of these vessels are the largest and most complex of their kind and require the careful solution of many novel problems.

(2) SENIOR DRAUGHTSMEN

Applicants should be experienced in pressure vessel work, preferably with some design experience. Minimum qualifications O.N.C.

Work involves the preparation and checking of layout and design drawings and the checking of fabrication drawings. The scope of the work is similar to that mentioned in (1). Suitable applicants will be required to undertake a certain amount of design work.

(3) JUNIOR DRAUGHTSMEN

Applicants who do not possess the experience required for posts in (1) and (2), yet who are interested in this field, will be considered for positions as Junior Draughtsmen. In the absence of other qualifications they should be studying for at least O.N.C.

All the above posts provide opportunities for advancement in a rapidly expanding industry, and attractive salaries will be offered to suitable applicants.

Appointments for interview may be made by telephone and interviews can be arranged in London, Manchester, Newcastle or Glasgow. Housing assistance can be given to suitable applicants and removal expenses will be paid. Holiday arrangements already made will be honoured. Written applications should be sent to the Personnel Manager (P.V.), The General Electric Company, Limited, Erith, Kent. Telephone, Erith 3011; Extension 45.

E8026 A

Classified Advts. continued on page 8

SITUATIONS VACANT

DESIGNER DRAUGHTSMEN

Men with flair for design work required by well-established and progressive Engineering firm in South West London. This Company is engaged in building Paper Making Machinery which presents interesting engineering problems. There are opportunities for studying equipment in the field, and working on new projects.

Applicants should have qualifications at least equal to Higher National Certificate. There is a pension scheme, and the prospects and salary are very good. Reply.—BOX No. E7930, "The Engineer." A

SITUATIONS VACANT

PRODUCTION MANAGEMENT

A company widely known in industry wishes to make an early appointment to its senior staff. The company's activities are closely interlinked with several new aspects of modern industry at home and abroad and offer broad and valuable experience to a man joining now. Qualifications required are a University Degree in Engineering or Science, experience of production, both executive and shop-floor, personal qualities of a high order and a strong desire to assume real responsibility at an early age and in return to advance quickly to the £3000-£4000 salary bracket. Age 28 to 35. This is a pensionable appointment. Please apply with brief details of age, education and experience in strictest confidence.—BOX No. E7998, "The Engineer." A

Designers & Draughtsmen

CIVIL & ARCHITECTURAL

Applications are invited from men with good experience in architectural and civil engineering work related to the design and construction of new industrial premises.

These are important posts in an interesting field of work, and are located at the Company's Offices in

HARLOW, ESSEX

Excellent conditions of service are offered including

ASSISTANCE WITH HOUSING

Local interviews can be arranged.

Applications in writing or by telephone giving full details of age, experience, qualifications and salary required should be made to:—

Staff Officer,

British Oxygen Engineering Ltd

Angel Road · Edmonton
LONDON, N.18
Tel: EDM 3020

E84 A

STRUCTURAL DESIGN ENGINEERS

AND

DESIGN DRAUGHTSMEN

A number of interesting vacancies are available with a Drawing Office engaged upon the design of overhead structures in connection with Railway Electrification contracts.

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PATENTS

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THE PROPRIETORS of Patent No. 693,530, for "IMPROVEMENTS IN OR RELATING TO METHODS OF SECURING A PIN IN A MEMBER," and No. 704,139, for "IMPROVEMENTS IN OR RELATING TO CONNECTIONS BETWEEN PINS AND BORES," desire to secure commercial exploitation by Licence or otherwise in the United Kingdom.—Replies to Haseltine Lake and Co., 28, Southampton Buildings, Chancery Lane, London, W.C.2. E8029 H

THE PROPRIETOR of British Patents Nos. 711,298, 711,299, 709,958, entitled "IMPROVED PLUG CLOSURES FOR HANDHOLES AND THE LIKE OF PRESSURE VESSELS," "A GATE VALVE WITH AN IMPROVED BONNET AND SEALING MEANS THEREFOR," and "IMPROVED PLUG CLOSURES FOR HAND AND LIKE HOLES IN PRESSURE VESSELS," offers same for Licence or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14, E. Jackson Boulevard, Chicago, 4, Illinois, U.S.A. E8027 H

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3, CASTLE STREET, CARDIFF.
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AIR PREHEATERS.—The South West Metropolitan Regional Hospital Board invites offers for the Purchase of Five Used Two-stage Power-driven Air Preheaters made by Boston Marine Patents Co. Limited, for Lancashire and Economic water-tube boilers, which are surplus to requirements. The equipment can be inspected at hospital boiler houses in Wiltshire and the Isle of Wight, and at the makers' works at Leeds.—Further details can be obtained from the Board at Highcroft, Romsey Road, Winchester. E8053 o

MODERN BAGNALL 0–6–0 Steam Locomotive with 18in. cylinders. Tractive effort 25,000 lb.—Full details from : Abelson and Co. (Engineers) Limited, Coventry Road, Sheldon, Birmingham, 26. Telephone No. : SHEldon 2424. E7949 o

Classified Advts. continued on page 10

FOR SALE

600

AIR COMPRESSORS

2450 c.f.m., BELLISS and MORCOM/BRIT. WESTINGHOUSE, vert., two-stage, two-crank, double acting, water cooled, suitable for 100 lb. sq. in. pressure, but with existing motor will deliver 2450 c.f.m. at 70 lb. W.P., 245 r.p.m., direct coupled 450 b.h.p. slipring induction motor 550/3/50, bell shields, overhung enclosed slip-rings, separate floor mounted vert. intercooler, overall dimensions 17ft. 3in. by 10ft. wide by 11ft. high at compressor from floor level.

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310 c.f.m. WORTHINGTON SIMPSON, Type DA36, vert., two-cyl., two-stage, water cooled, W.P. 100 lb. sq. in. 930 r.p.m., driven by 80 h.p. slipring motor by Crompton Parkinson 400/3/50, with control gear, alternatively can be supplied with a larger motor to give 150 lb. W.P., 298 c.f.m., at 960 r.p.m.

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EUSton 4681. E7974 G

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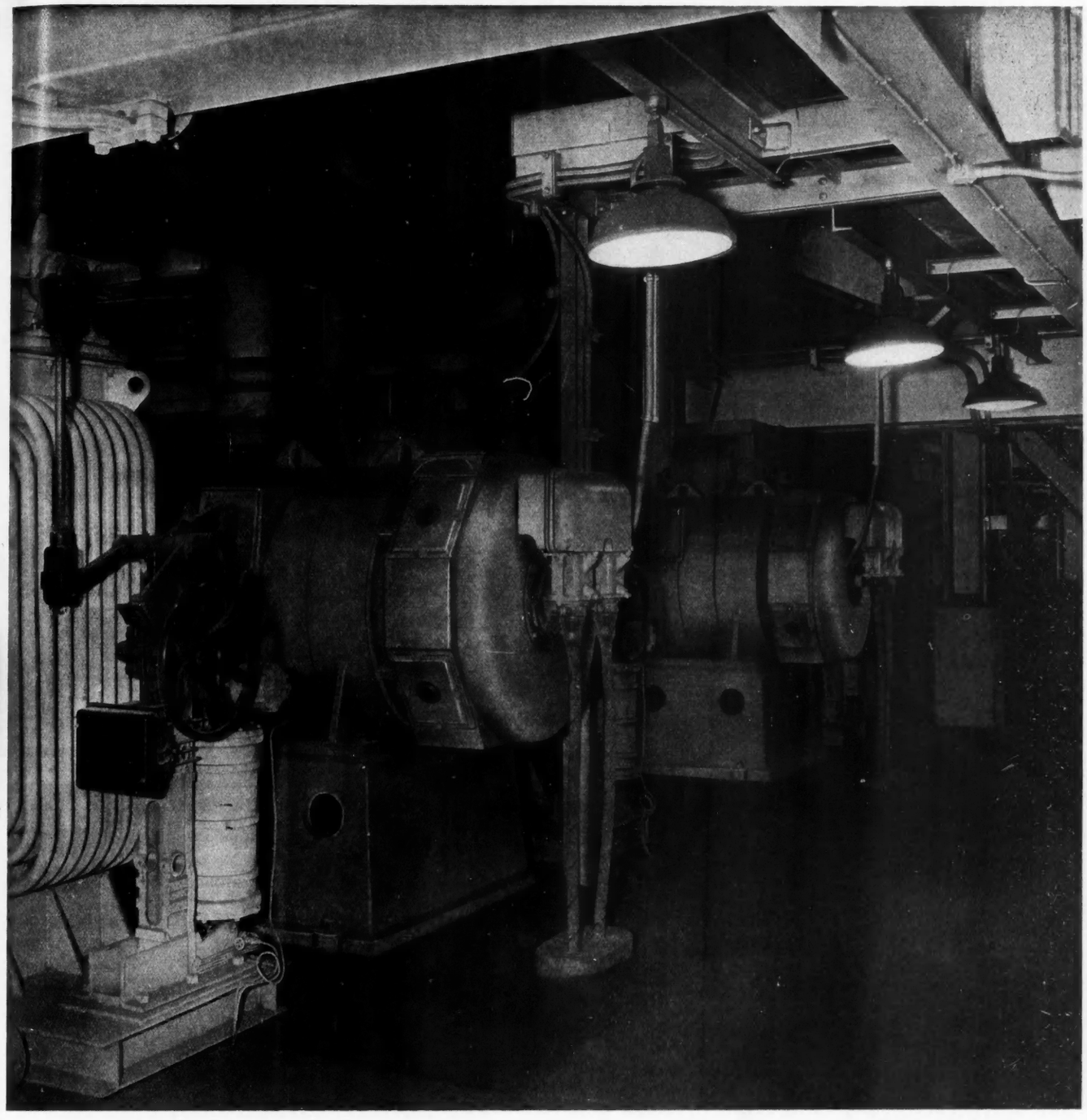

Two of the nine N-S exhauster motors at Pyrmont (Australia) power station. The motors are of 100/28 h.p., 1,475/920 r.p.m., with their induction (speed) regulators actuated by Bailey regulators.

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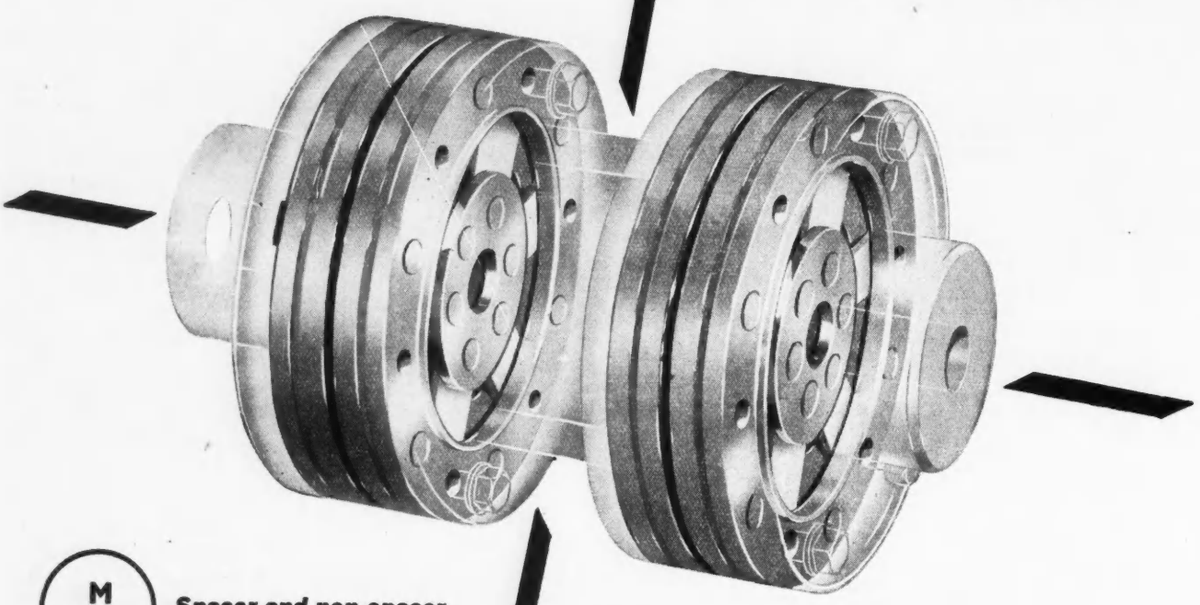

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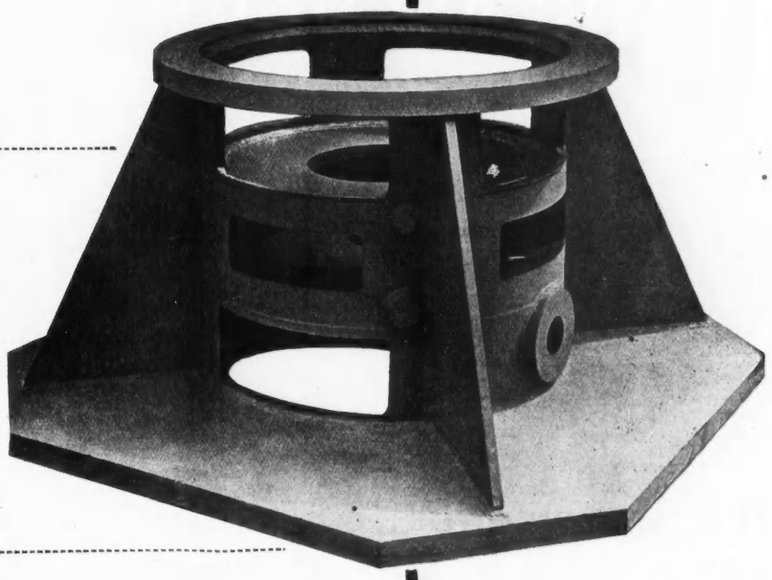

A Fabricated Mild Steel Vertical Thrust Housing with Oiltight Chamber. Machining allowance of ¼" on all finished surfaces.

Photograph by courtesy of Michell Bearings Ltd., Newcastle-upon-Tyne.

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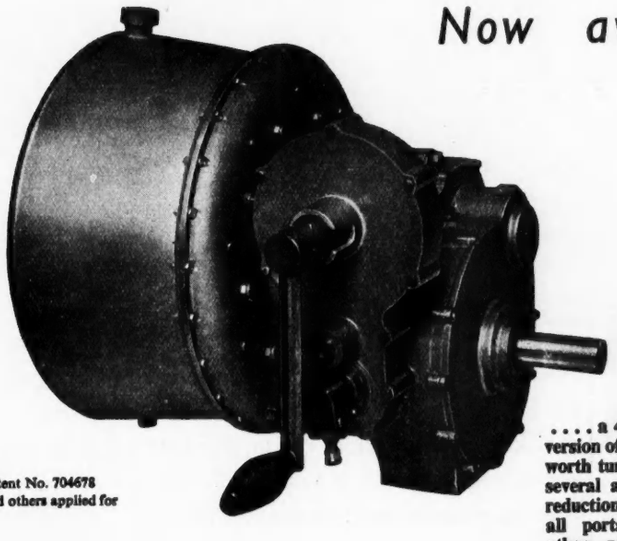

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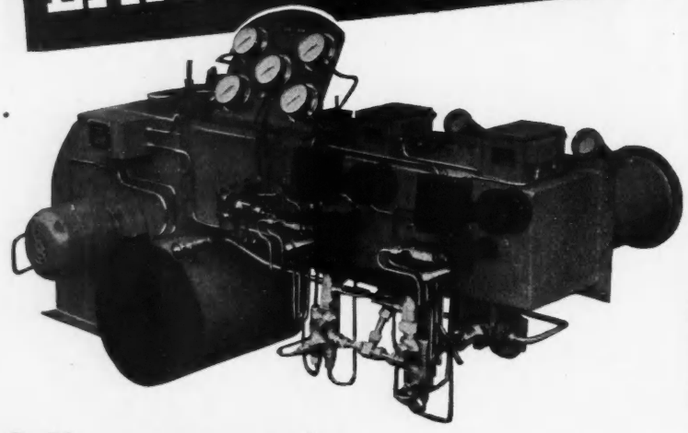

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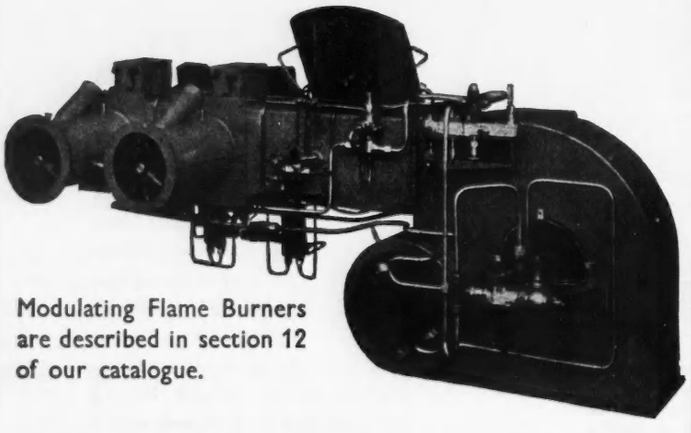

Modulating Flame Burners are described in section 12 of our catalogue.

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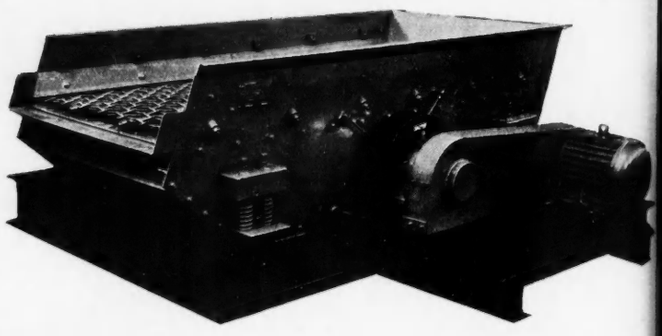

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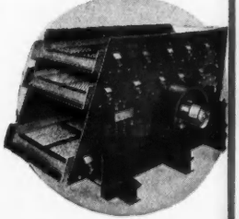

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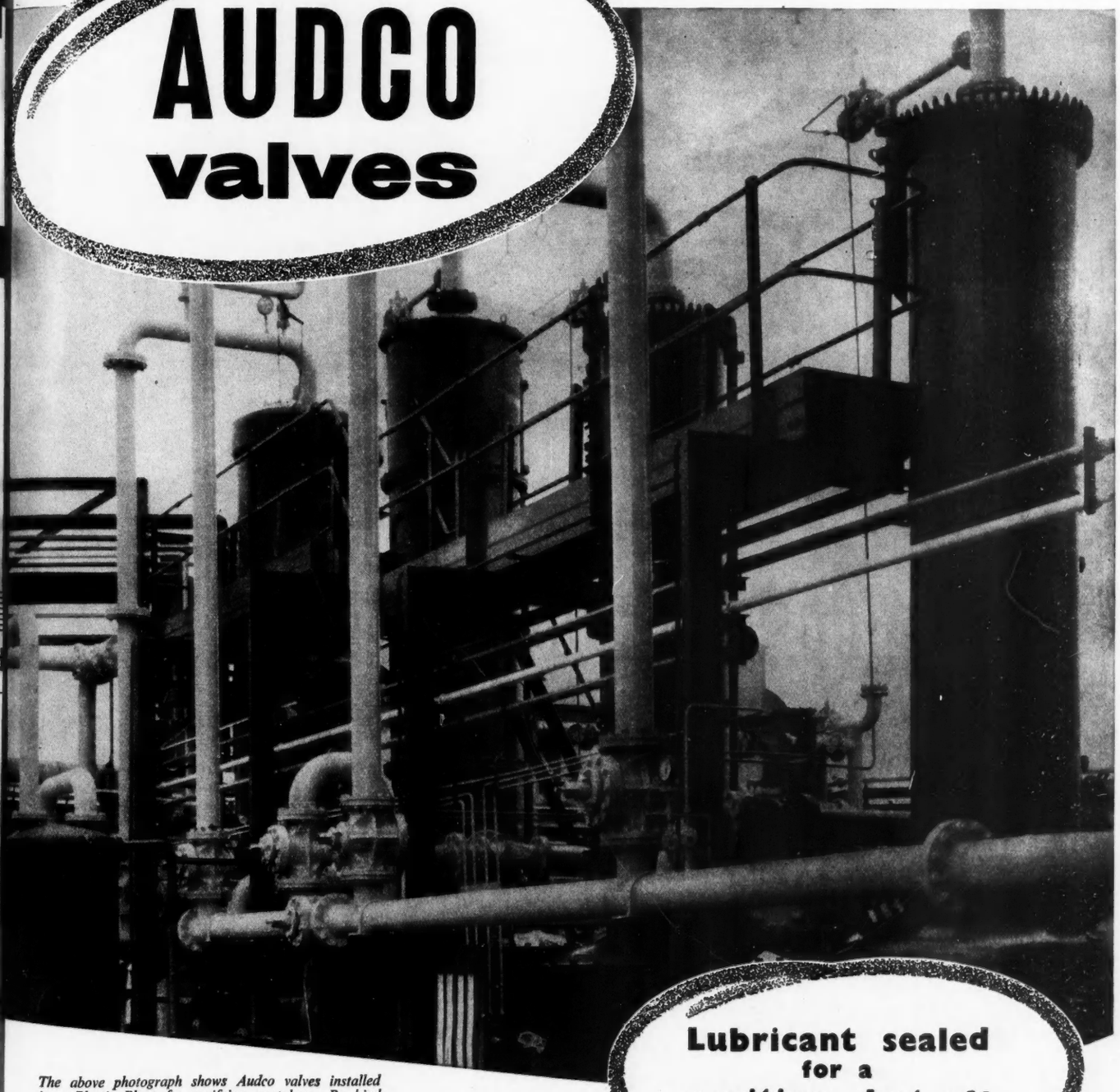

The above photograph shows Audco valves installed in a Plastic Plant for purifying acetylene. By kind permission of British Geon Limited.

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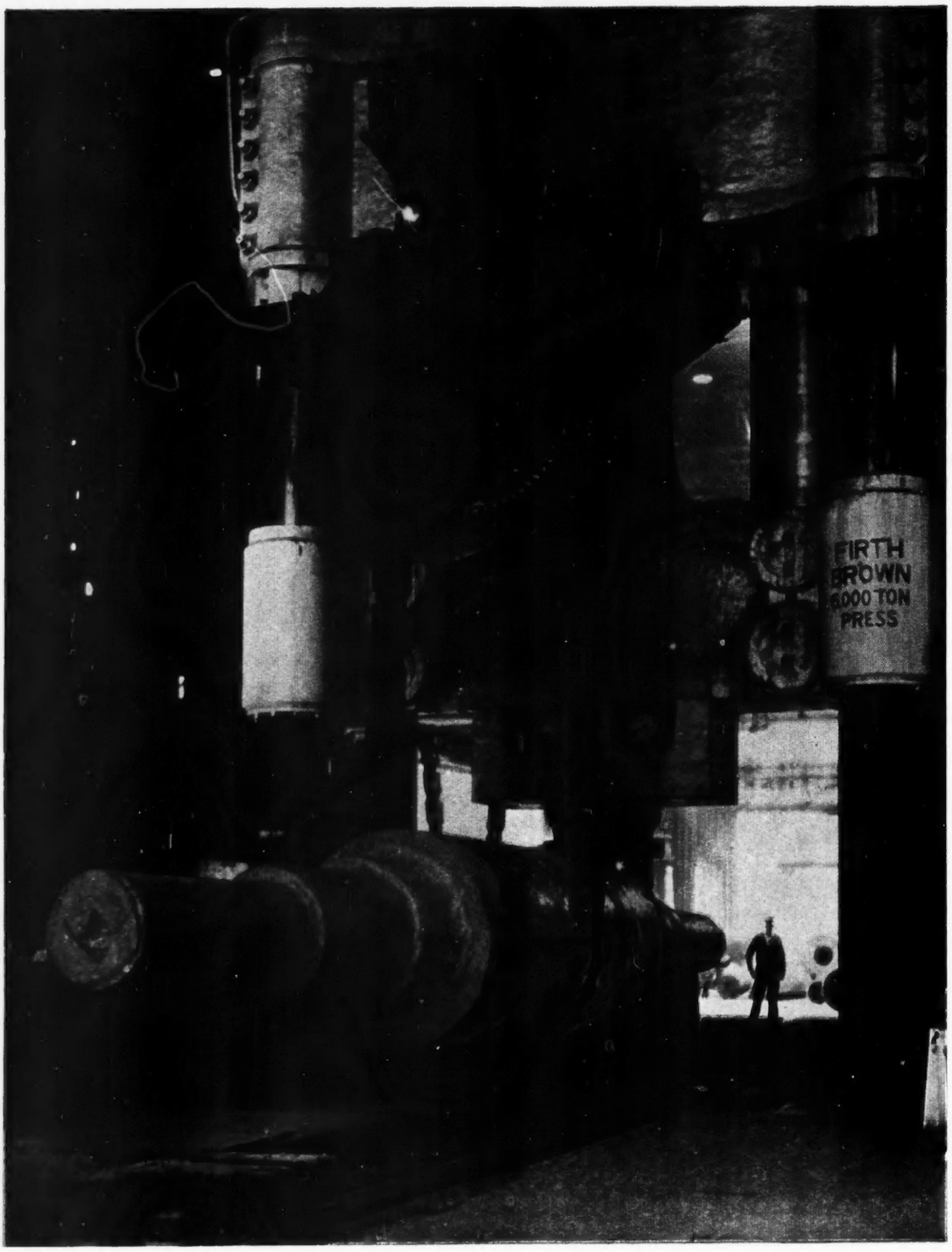

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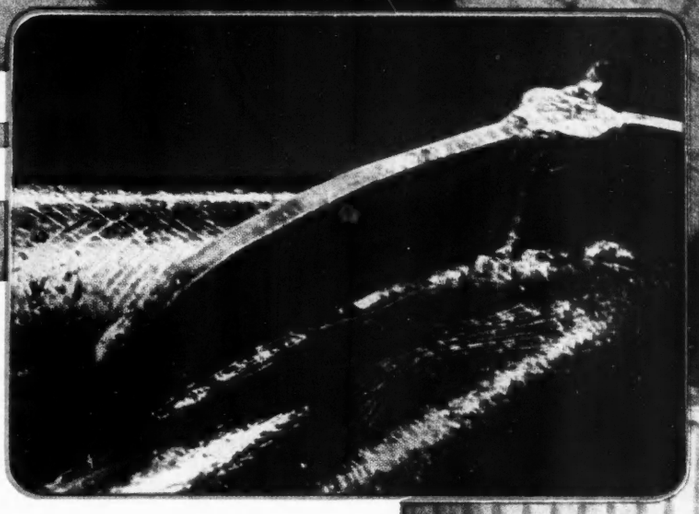

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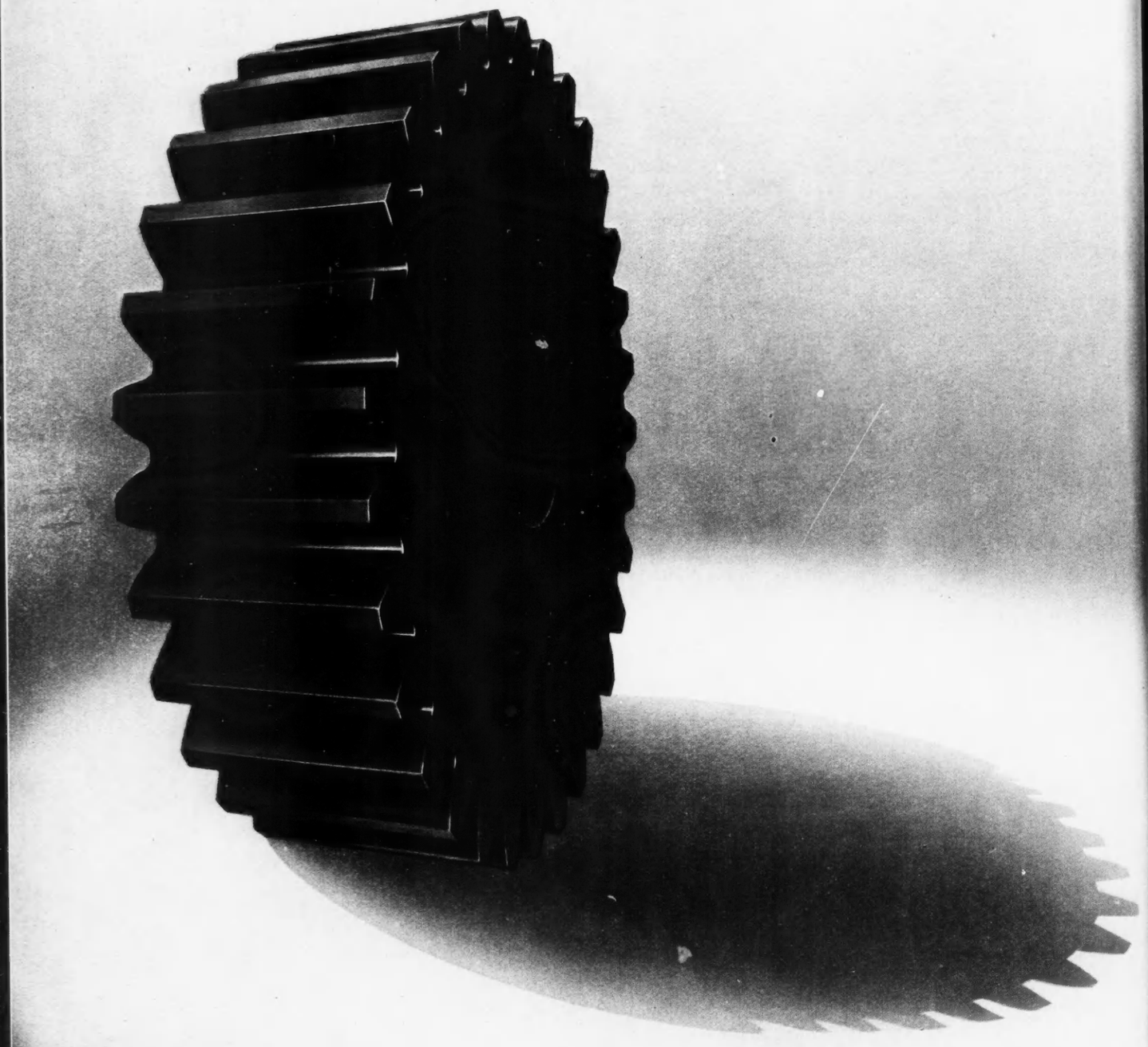

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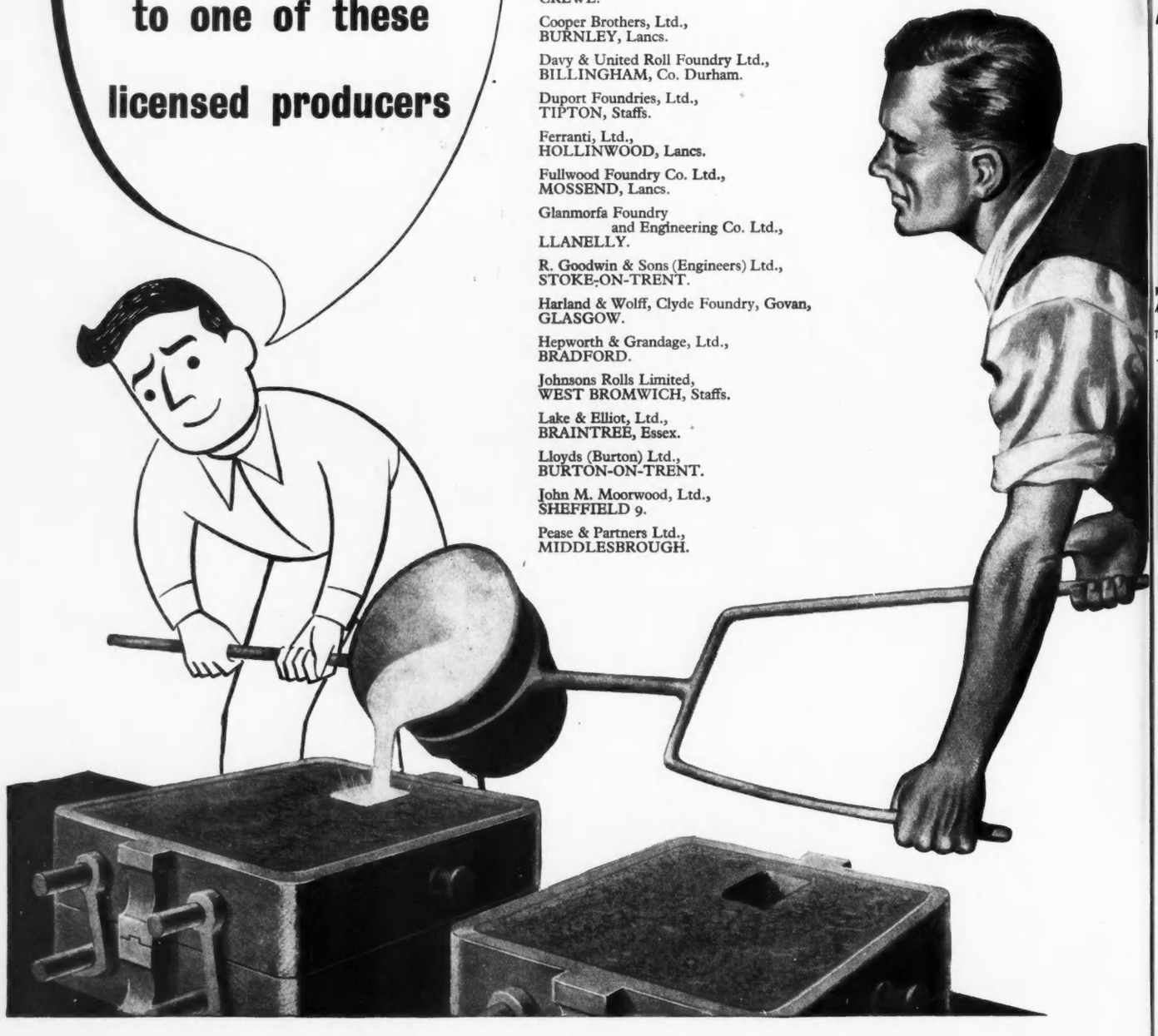

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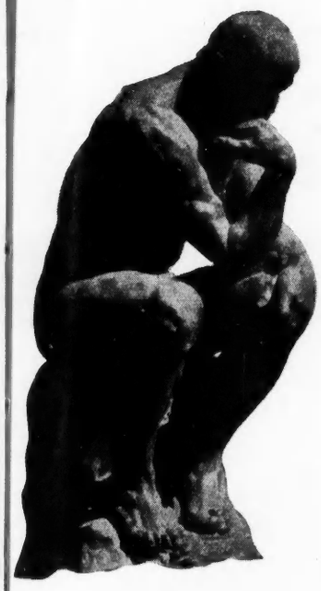

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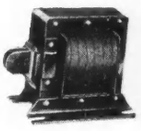

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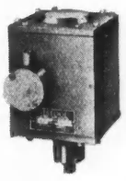

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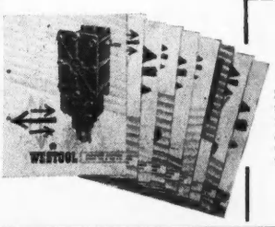

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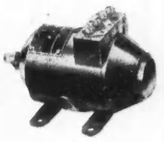

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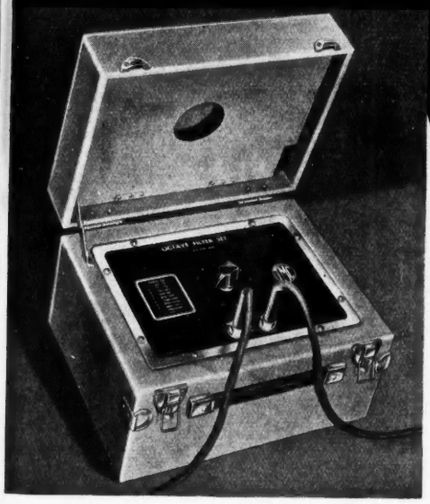

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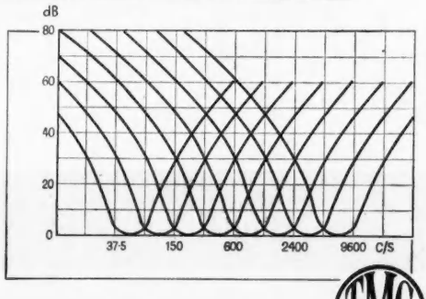

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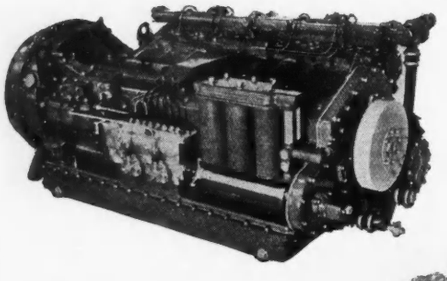
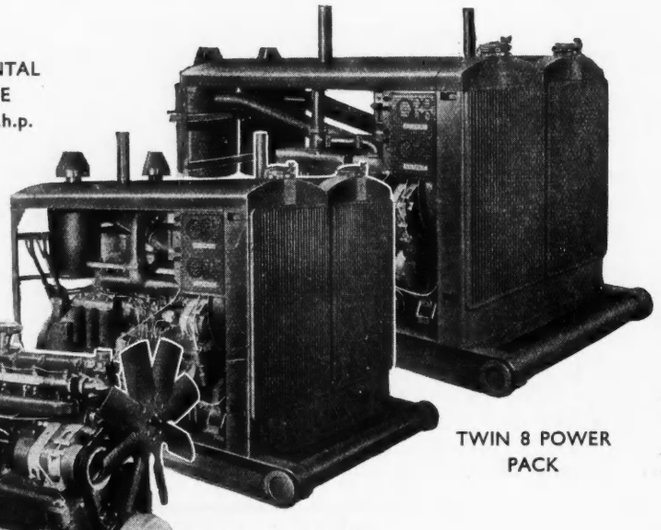
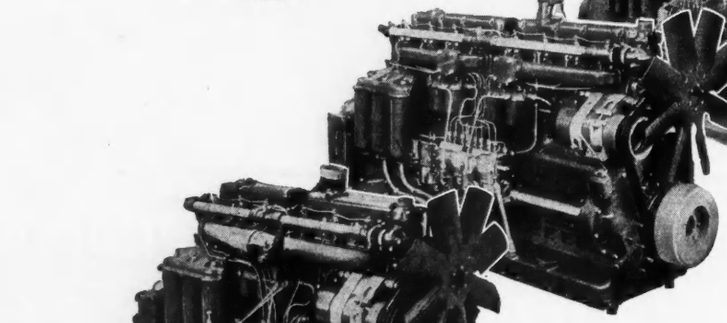


HORIZONTAL ENGINE
100-300 b.h.p.

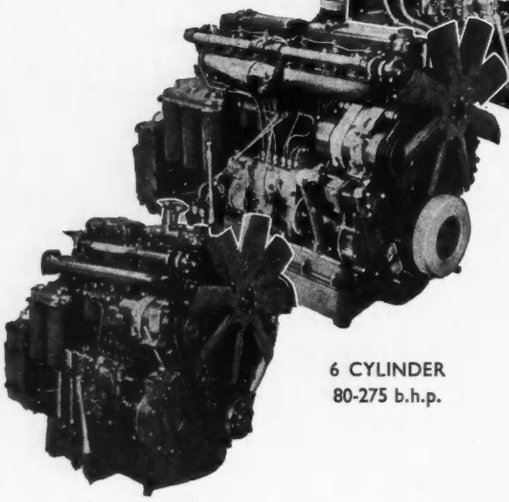


TWIN 8 POWER PACK

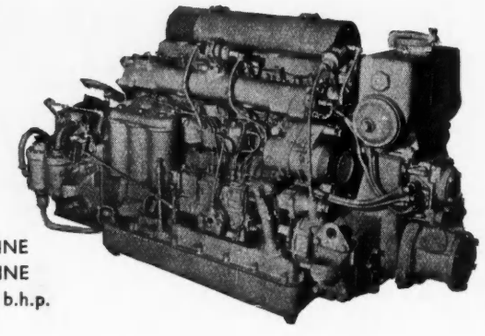


TWIN 6 POWER PACK

8 CYLINDER
100-333 b.h.p.



6 CYLINDER
80-275 b.h.p.



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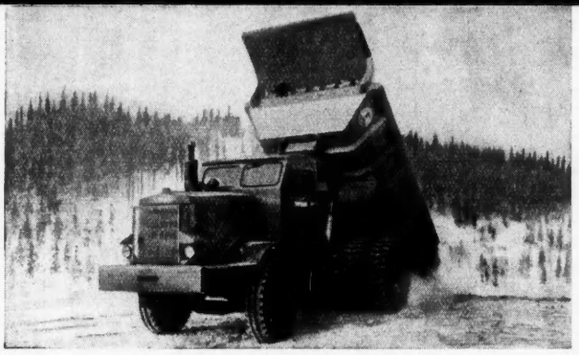
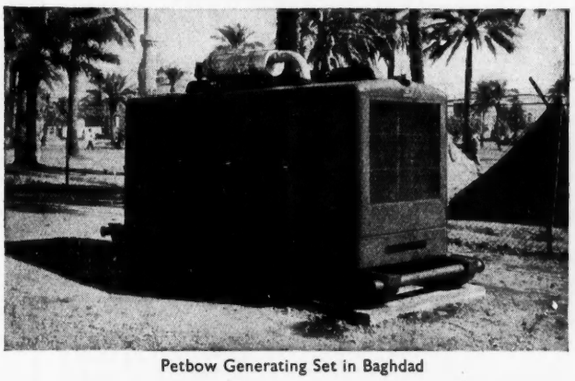


Euclid Dumper in Sweden

C.P.T. Air Compressor in England



Petbow Generating Set in Baghdad

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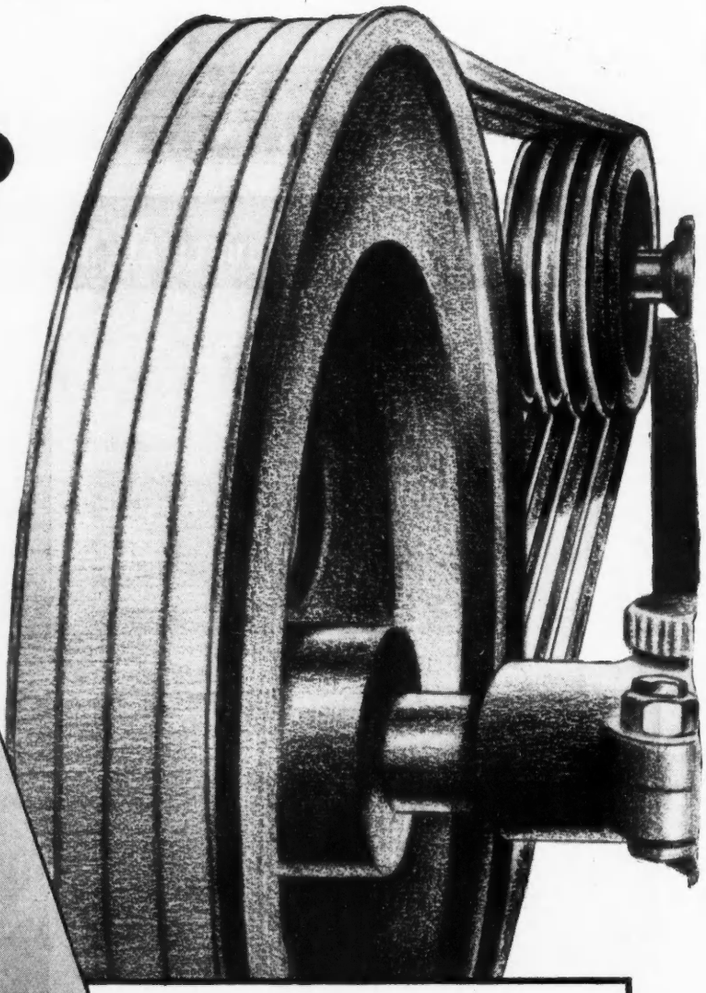
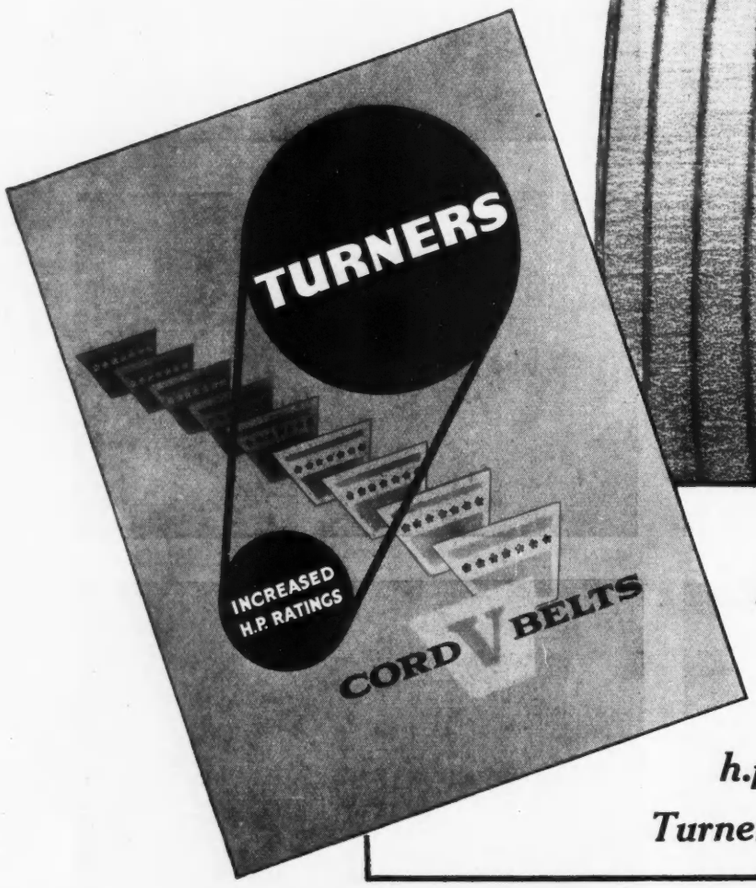
INCREASED H.P. RATINGS





Send for Broadsheet BA56/G giving complete mechanical data and details of increased h.p. ratings achieved using Turners Rayon Cord 'V' Belts

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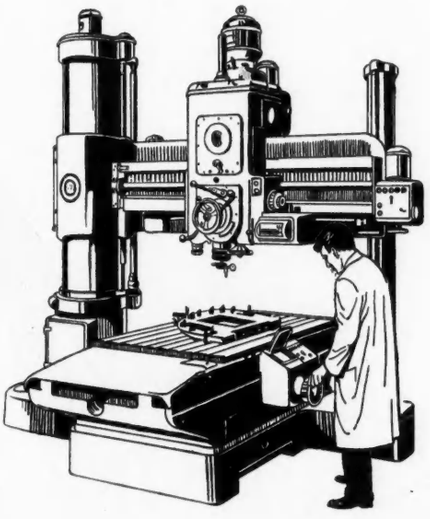

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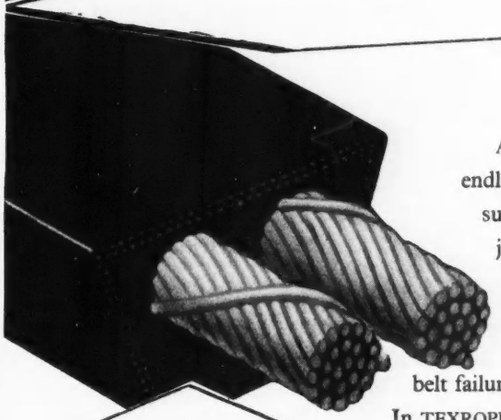

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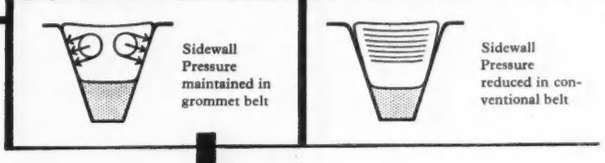

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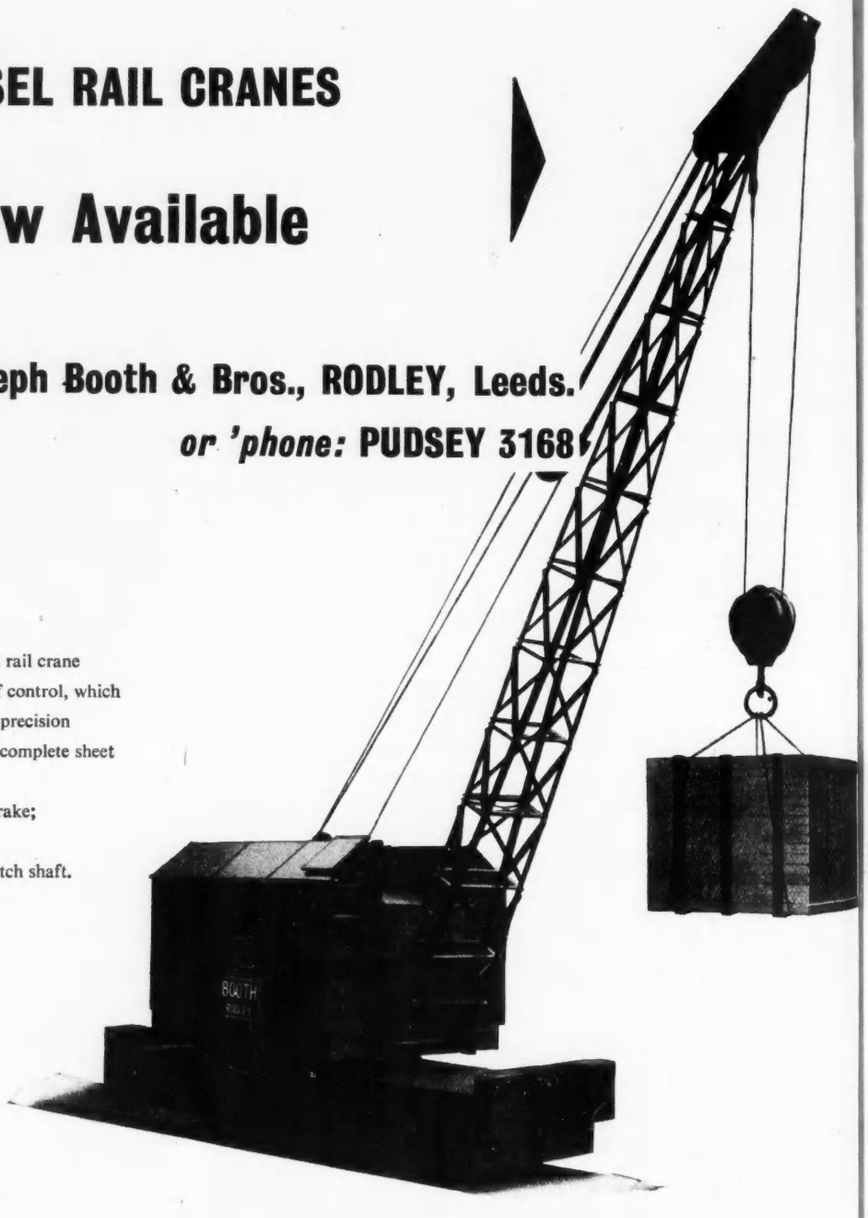

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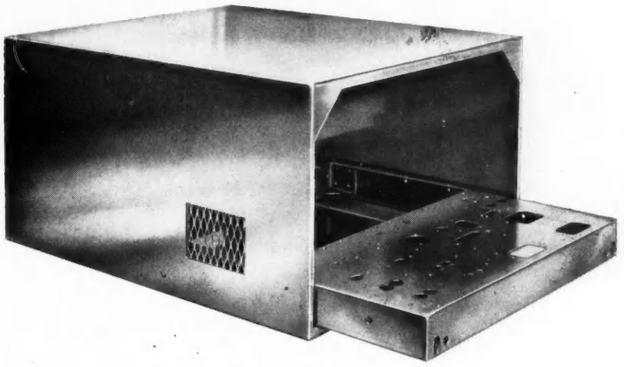

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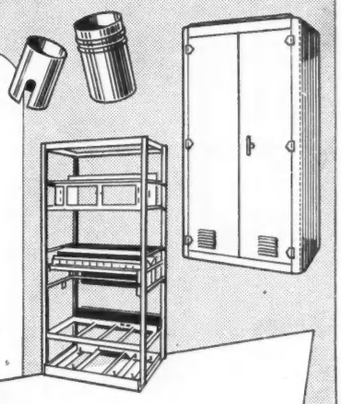

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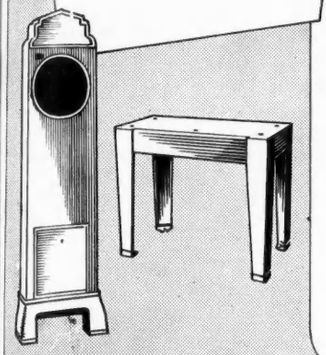

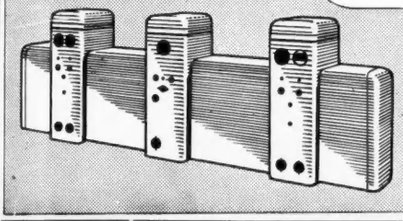

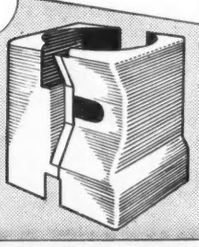

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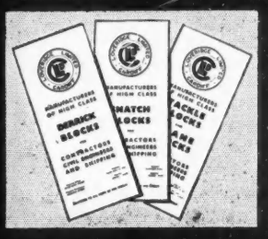

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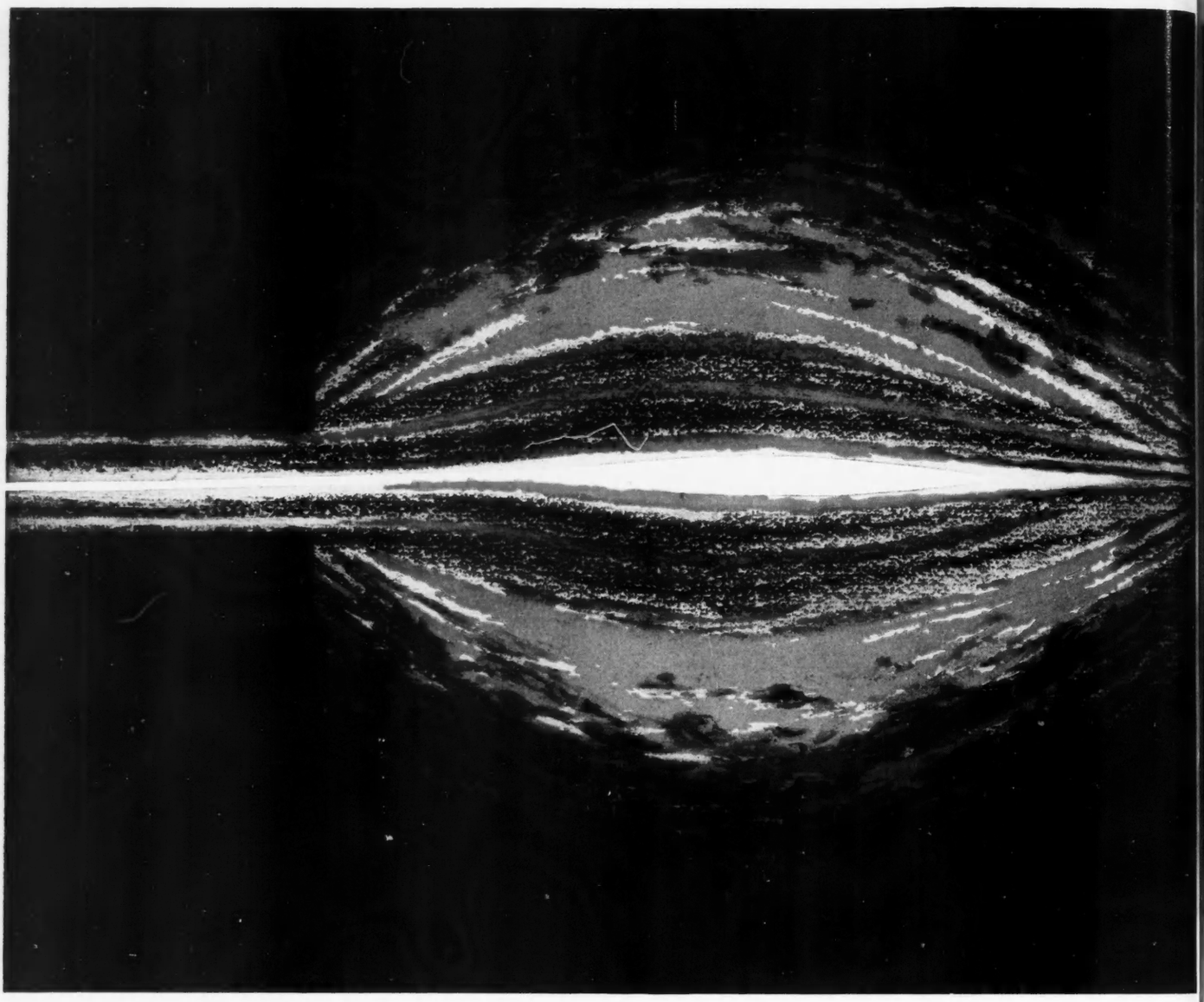

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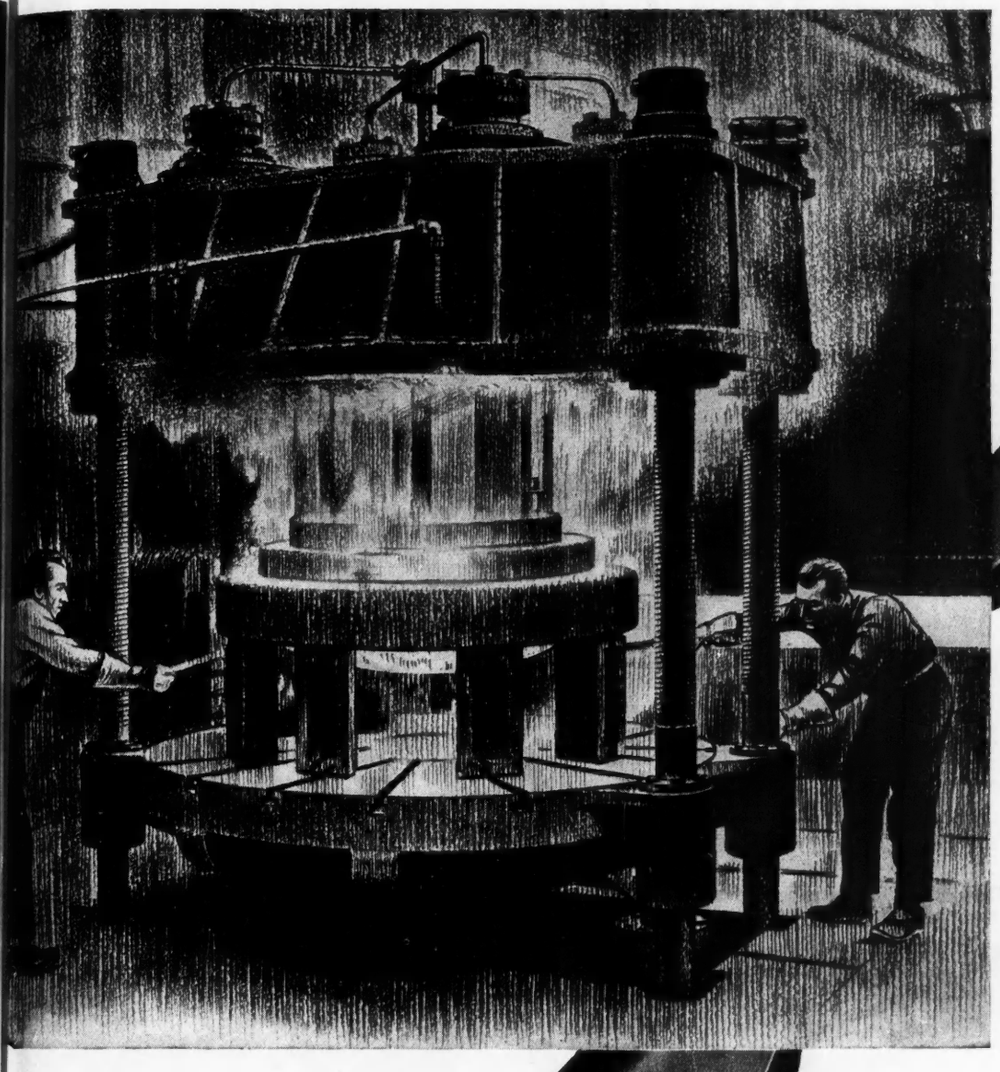
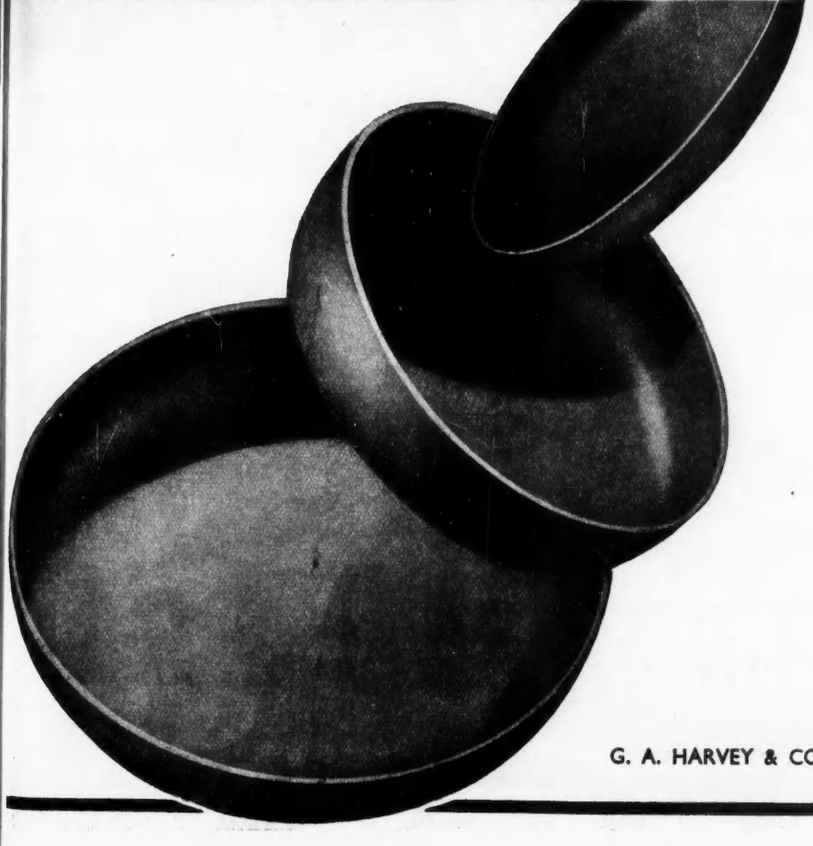


DISHED and FLANGED ENDS



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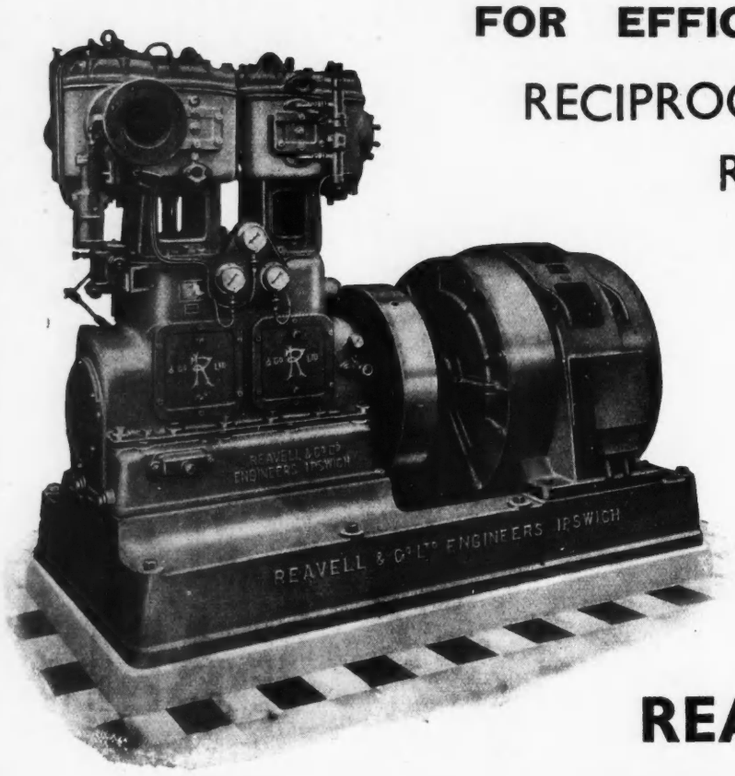

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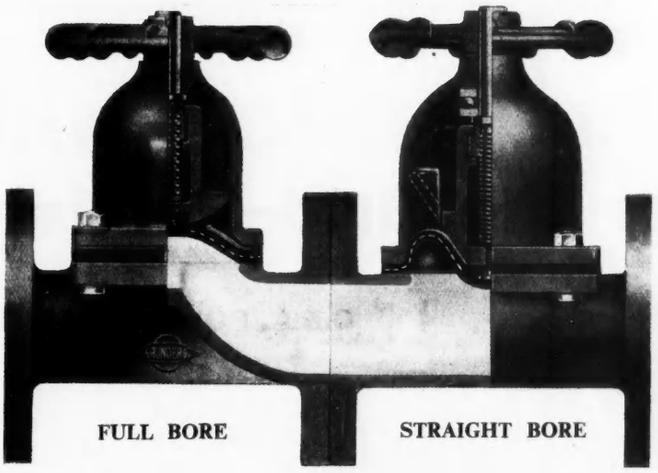

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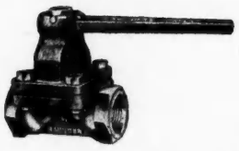

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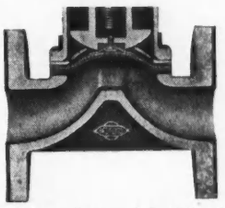

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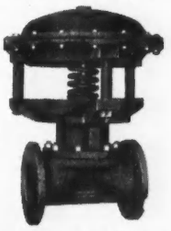

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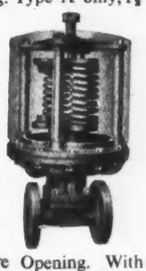

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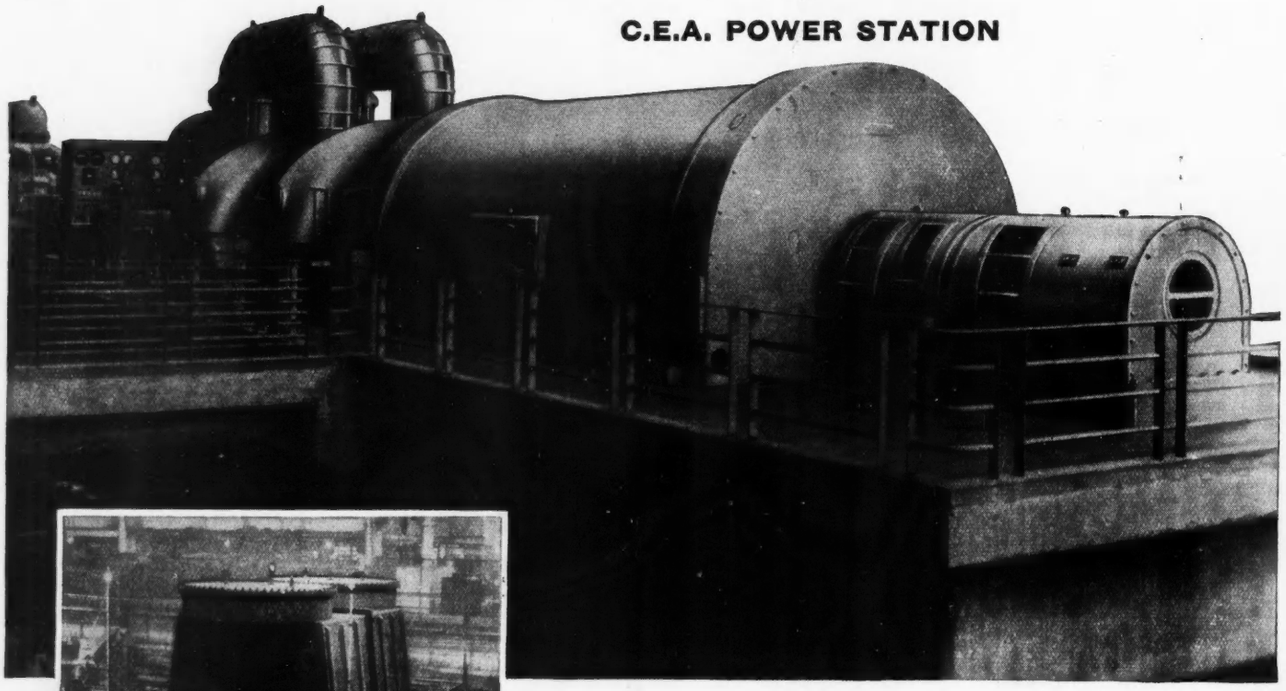
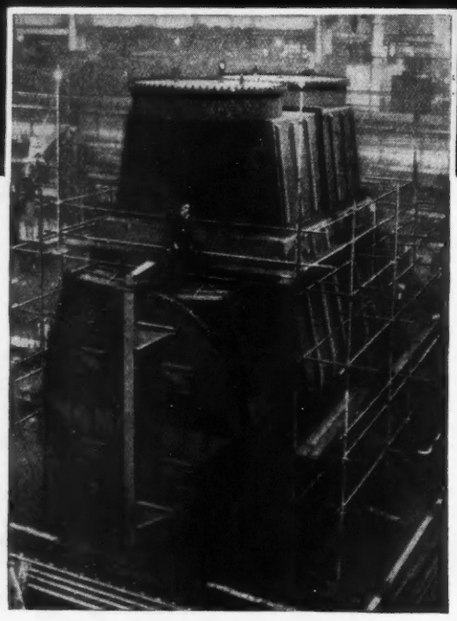
Power for the Grid–Portishead 'B'

C.E.A. POWER STATION





Metropolitan-Vickers are to supply six 60 MW steam turbine-generating sets to the C.E.A. Portishead "B" Power Station. These two-cylinder close-coupled steam turbines drive 75 MVA hydrogen-cooled generators, and the first two sets are now in service. The turbines are suitable for two-shift operation and are direct-coupled to the generators, which produce 50 cycle, 3-phase current at 11,800 volts.

The turbines have initial steam conditions of 900 psig, 900°F, and exhaust to single-shell central flow condensers which, in this station, have to be installed some 69 ft. below the turbines. The condensers, together with the five-stage feed water heating equipment are also being supplied by Metropolitan-Vickers.

The illustration shows a single-shell condenser under construction. Six of these units, each having a cooling surface area of 60,000 sq. ft., are being supplied for the installation.

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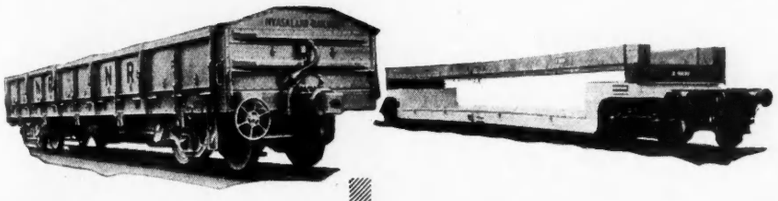

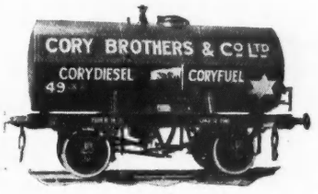

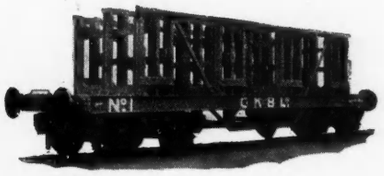

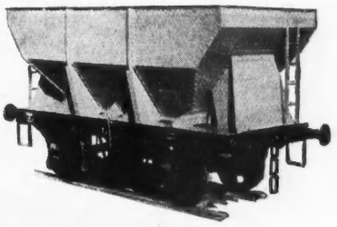

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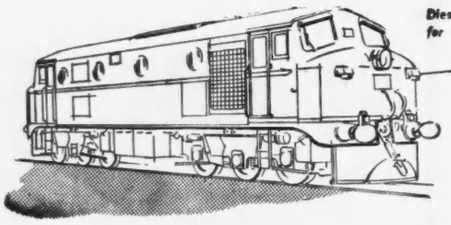
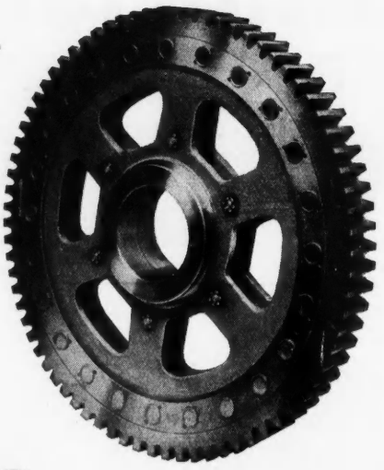


Diesel locomotive built by Messrs. Brush Bagnall Traction Ltd. for Ceylon incorporating Wiseman resilient gear wheels.

and resilient final drive by Wiseman



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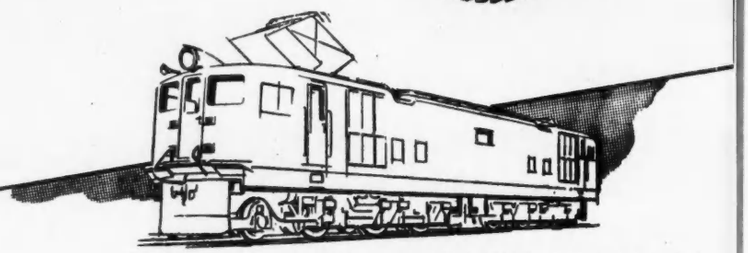

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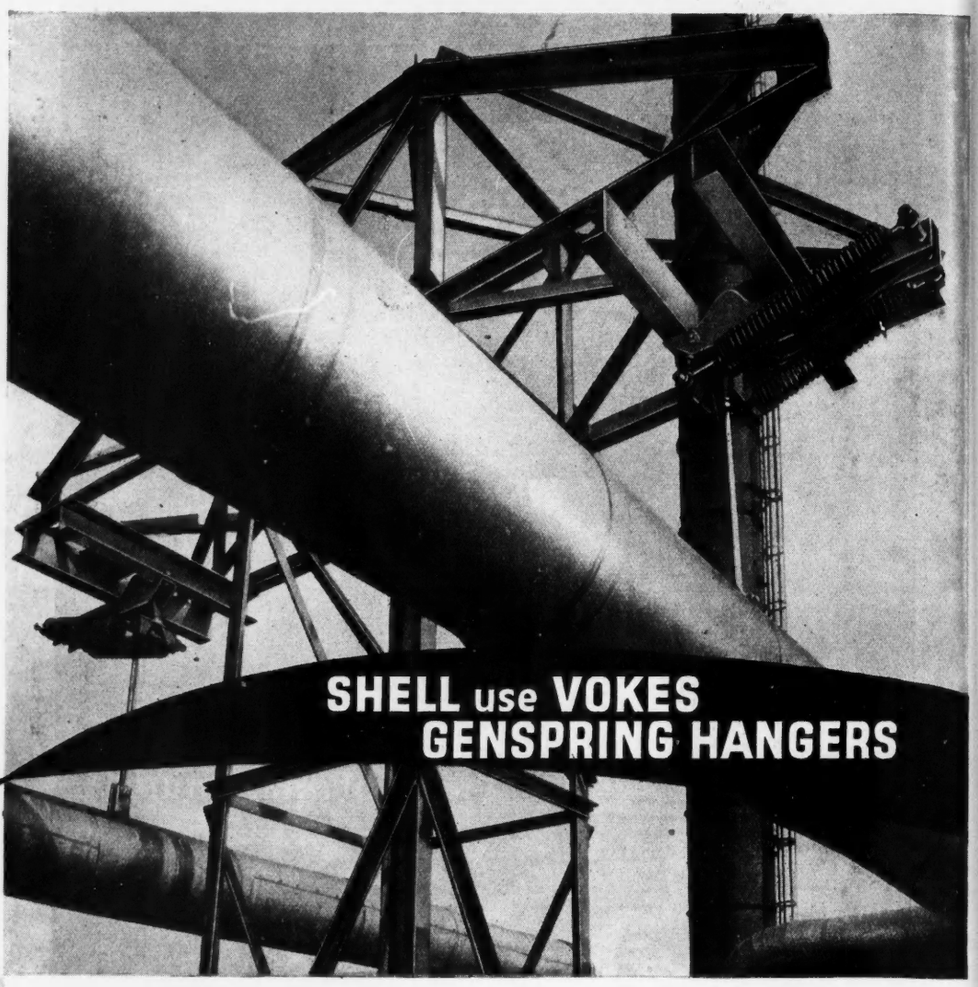

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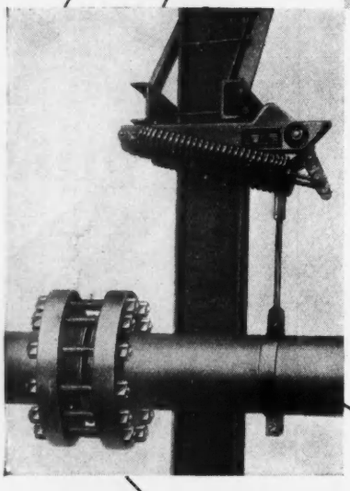

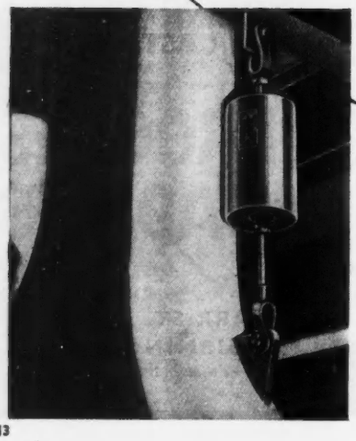

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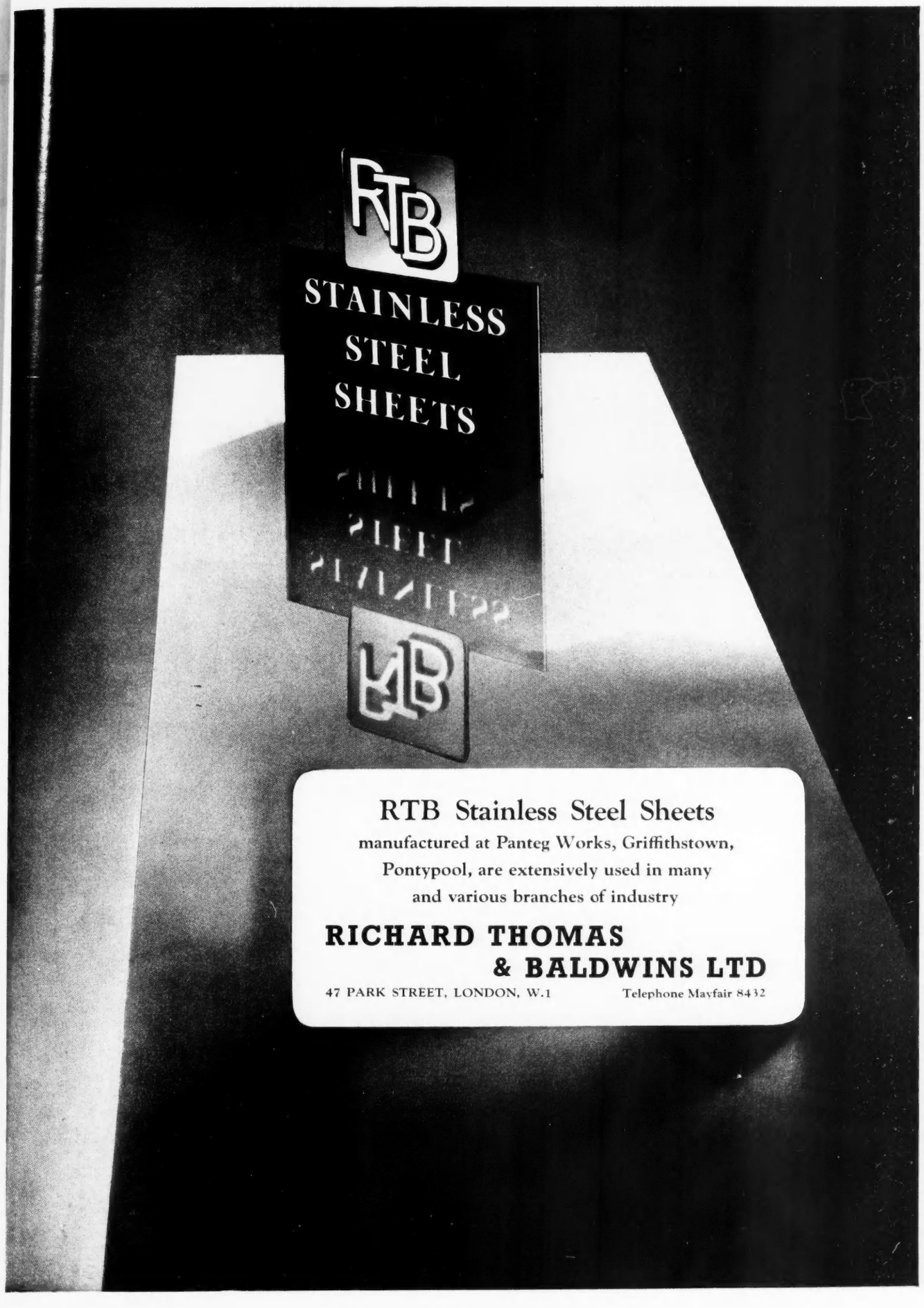

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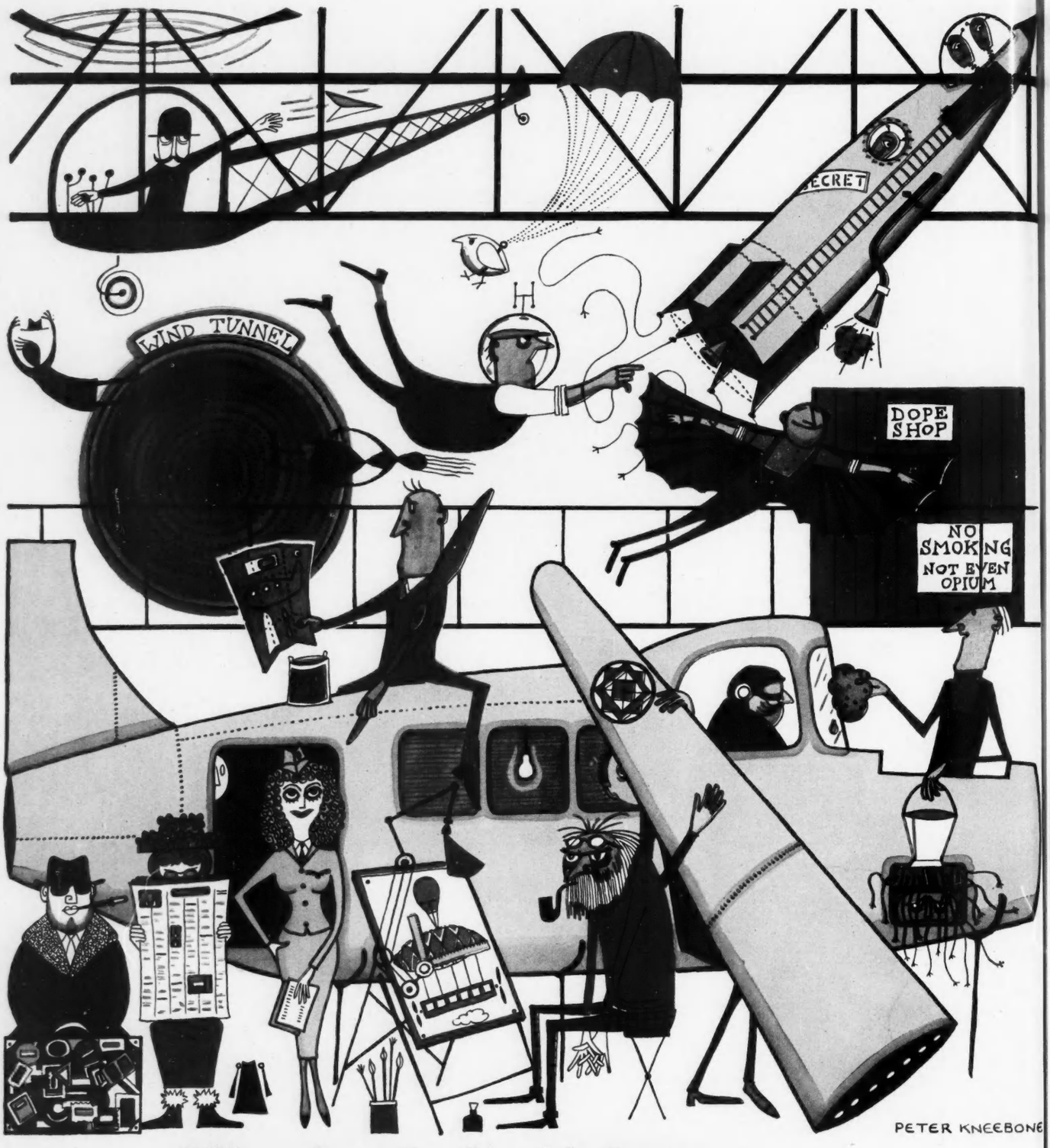

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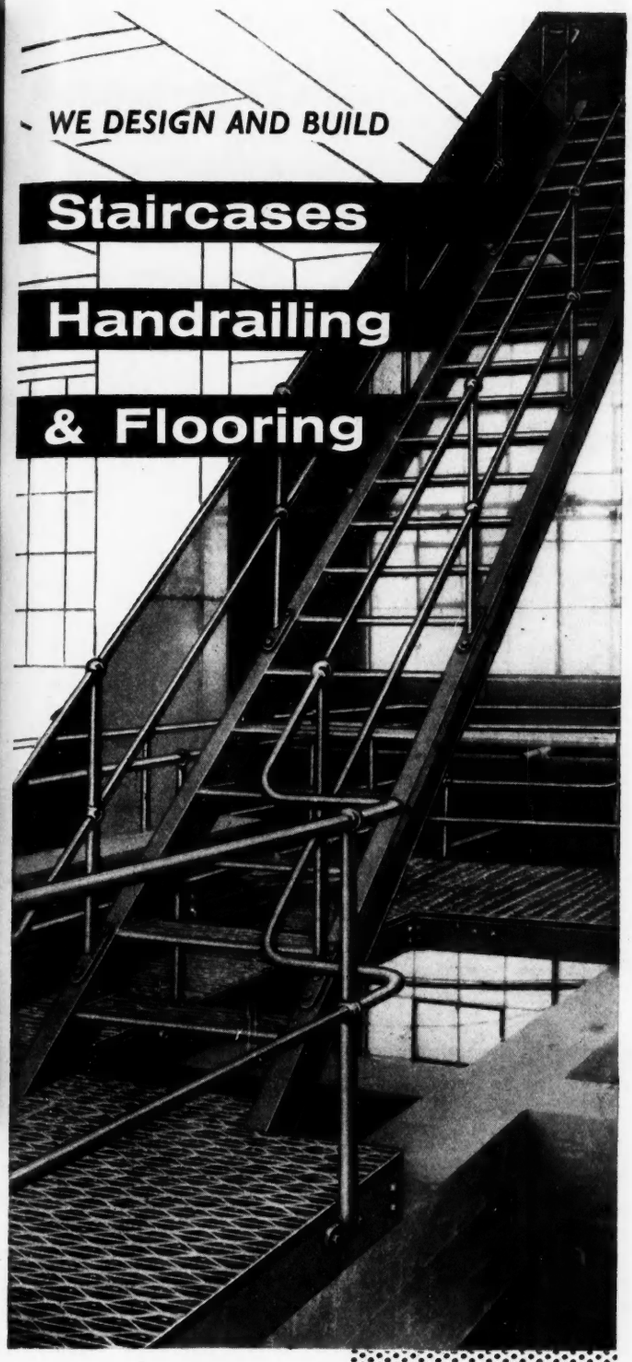

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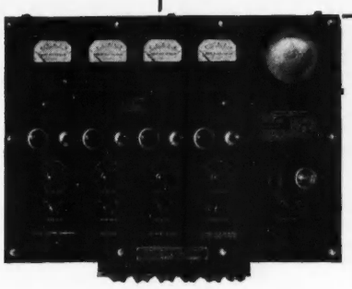

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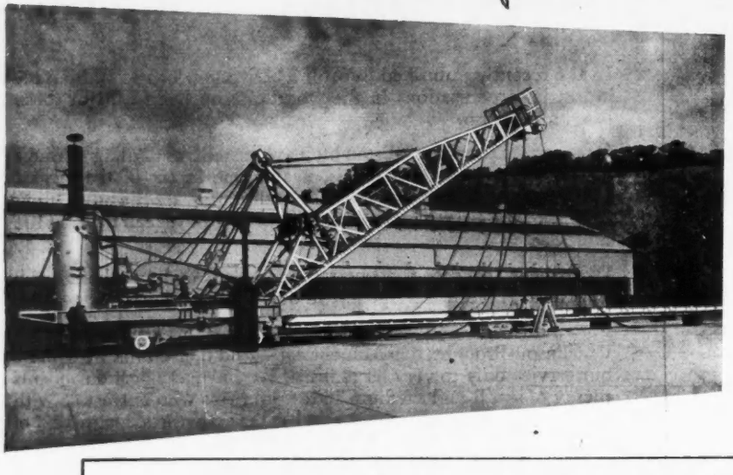

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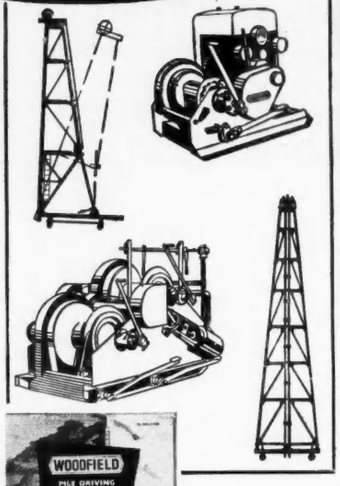

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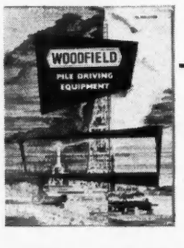

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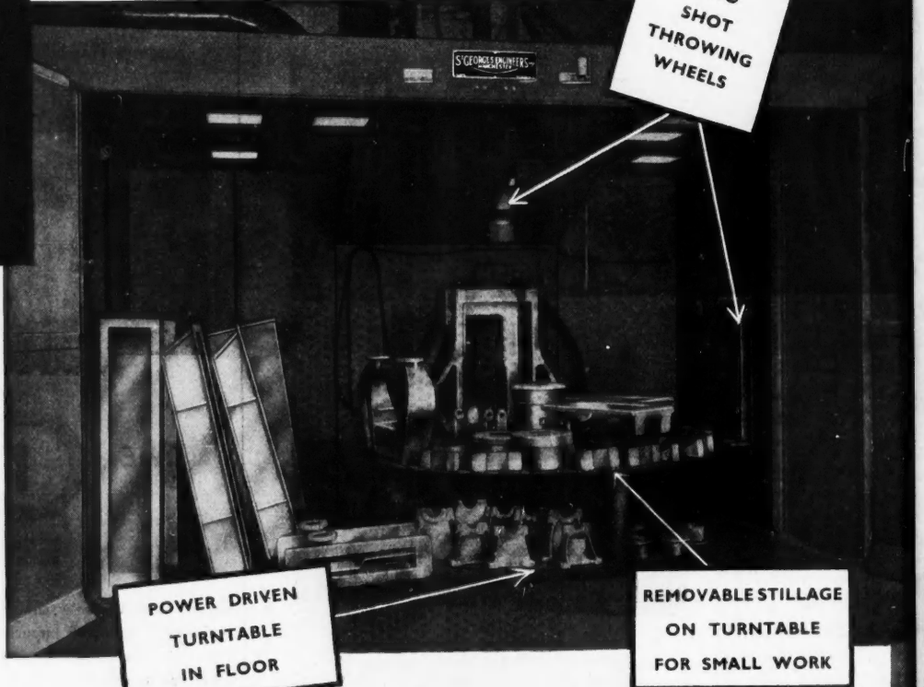

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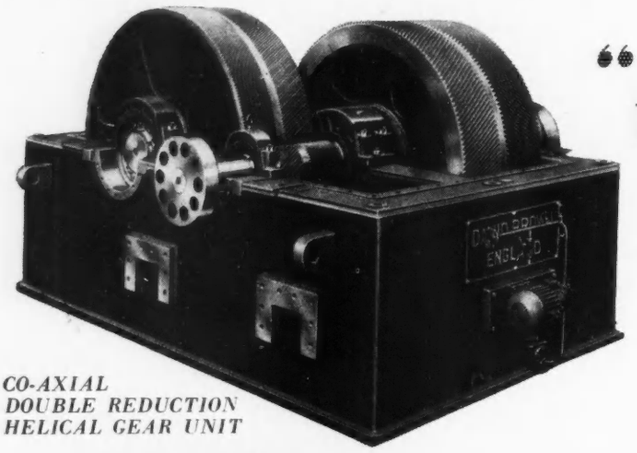

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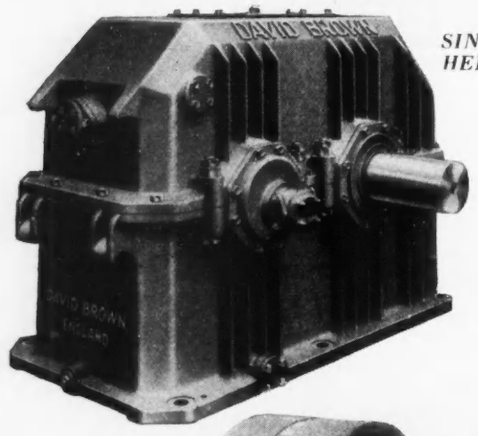

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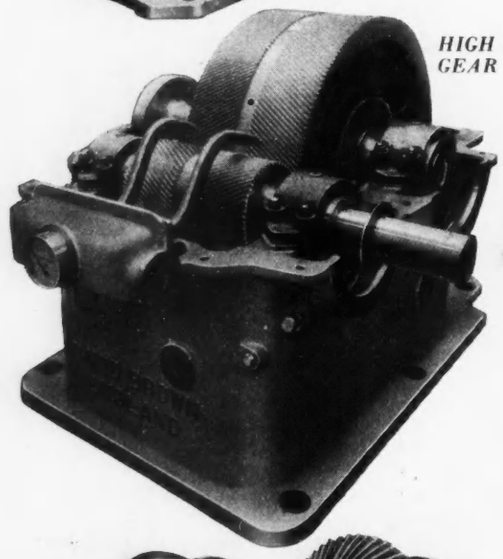

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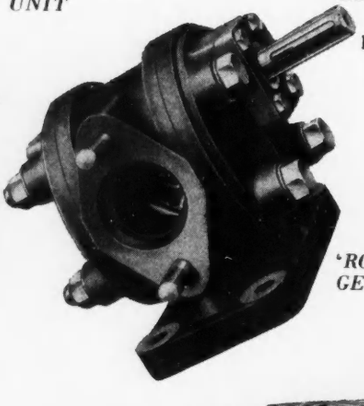

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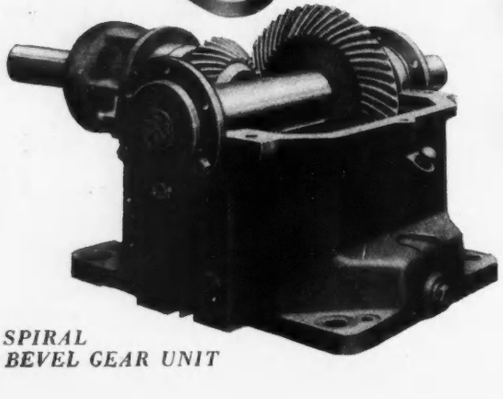

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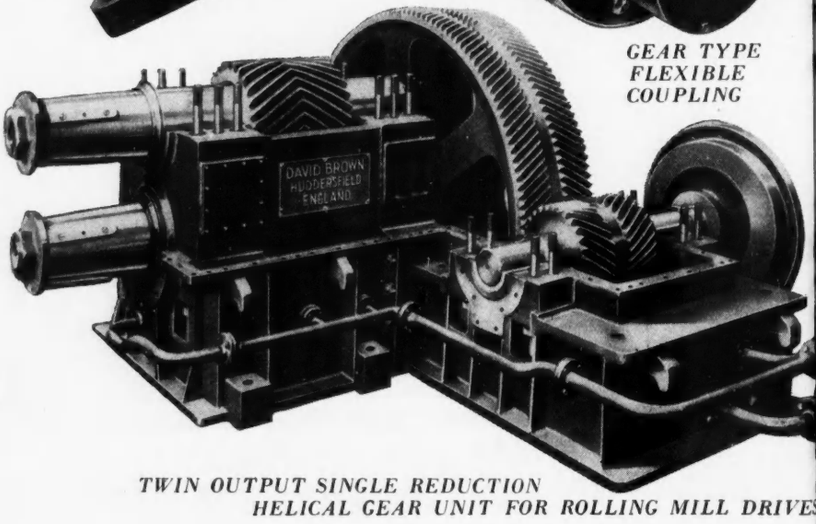

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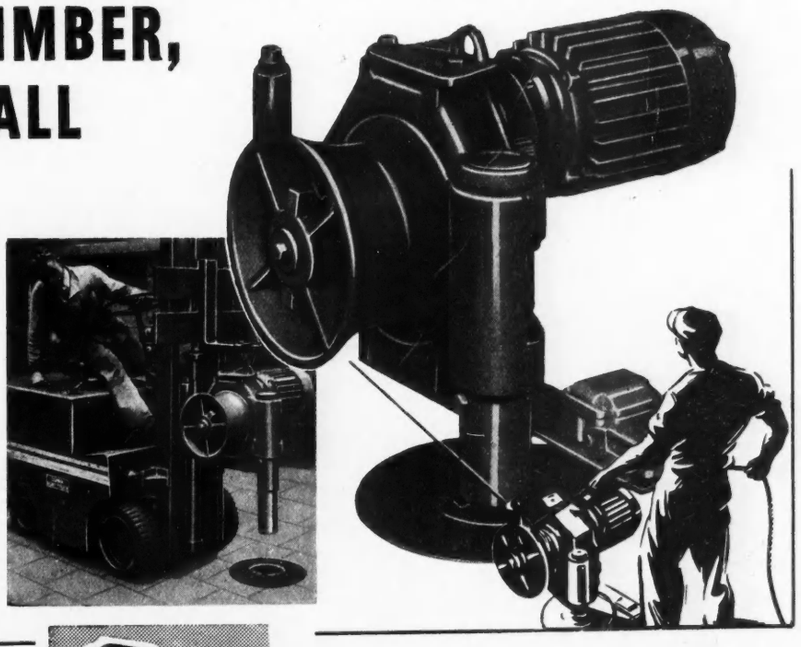

Photograph illustrates unit being lifted from ground socket by Standard Fork Truck.

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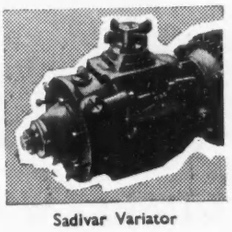

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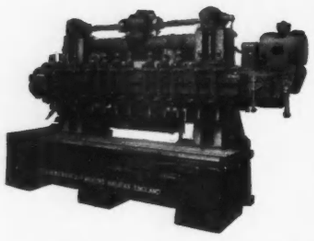
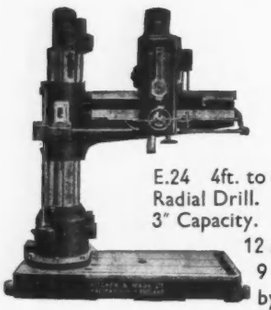
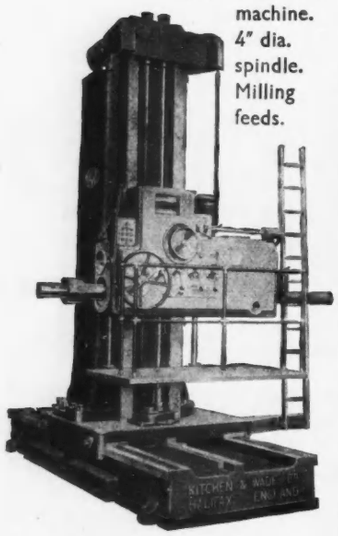


L.7 In line multiple spindle machine with automatic cycle.



E.24 4ft. to 6ft. Radial Drill. 3" Capacity. 12 speeds, 9 feeds, by single lever.

H.12 Pipe flange facing machine. Table has rapid traverse and power feeds.



H.6 Horizontal machine. 4" dia. spindle. Milling feeds.

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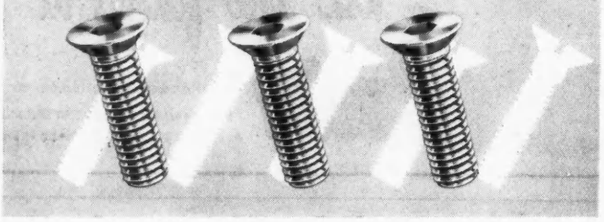
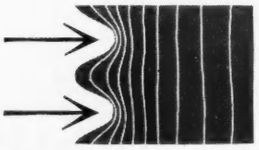


Calculating loads and stresses is increasingly important in modern screw design. Machines operate at higher speeds under heavier loads, materials are subjected to greater stresses. Screws are required to do more and better work.

Failure due to repeated stresses on a bolt are located at the point of higher stress concentration. These points are usually the head to shank junction or the threaded section.



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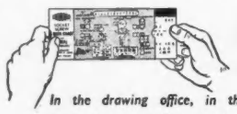

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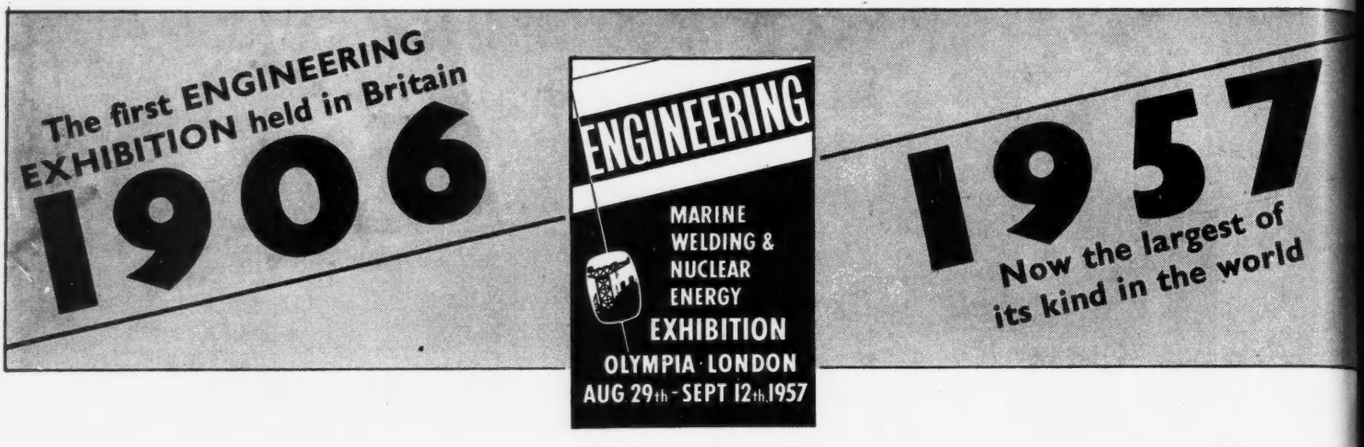
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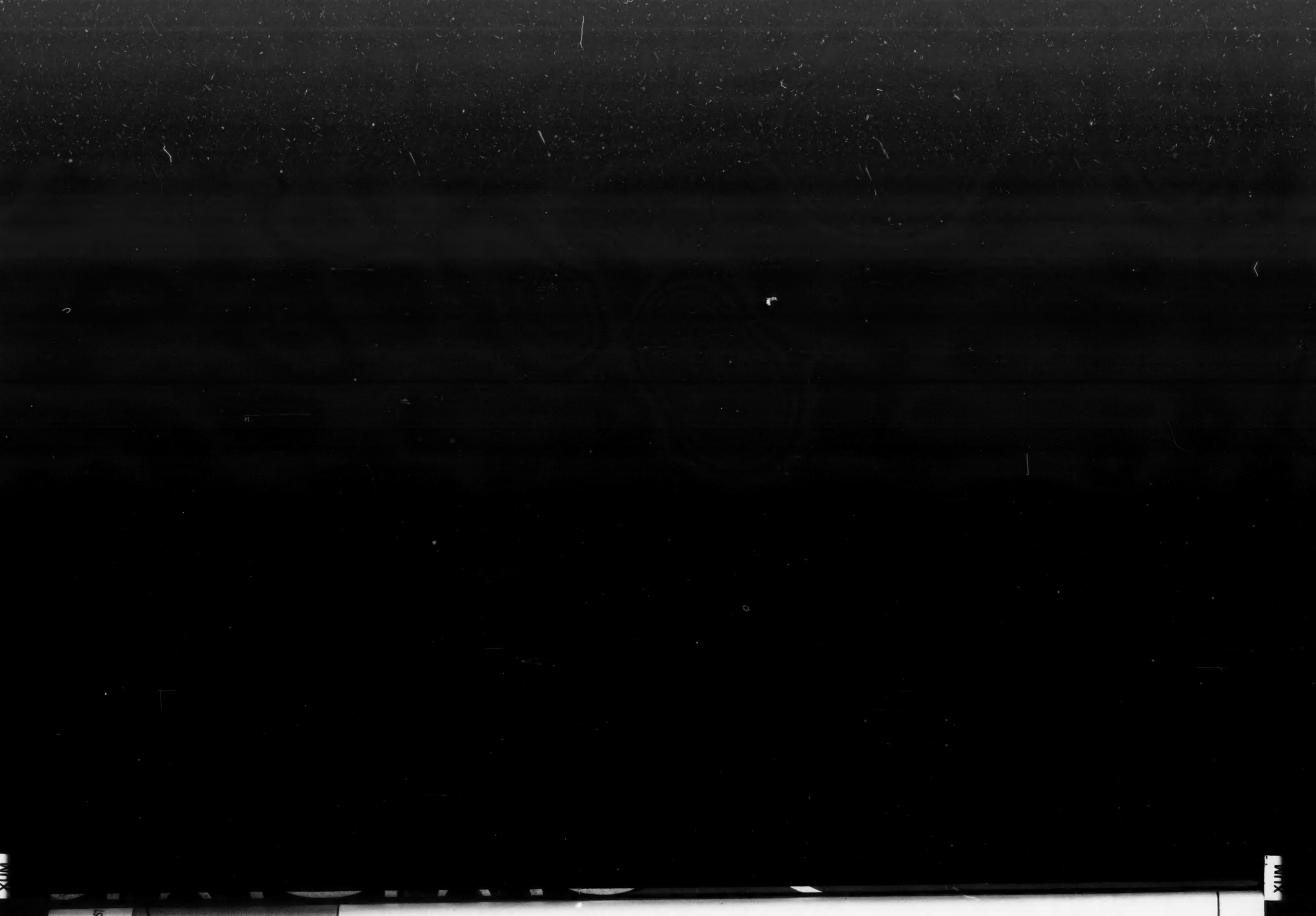

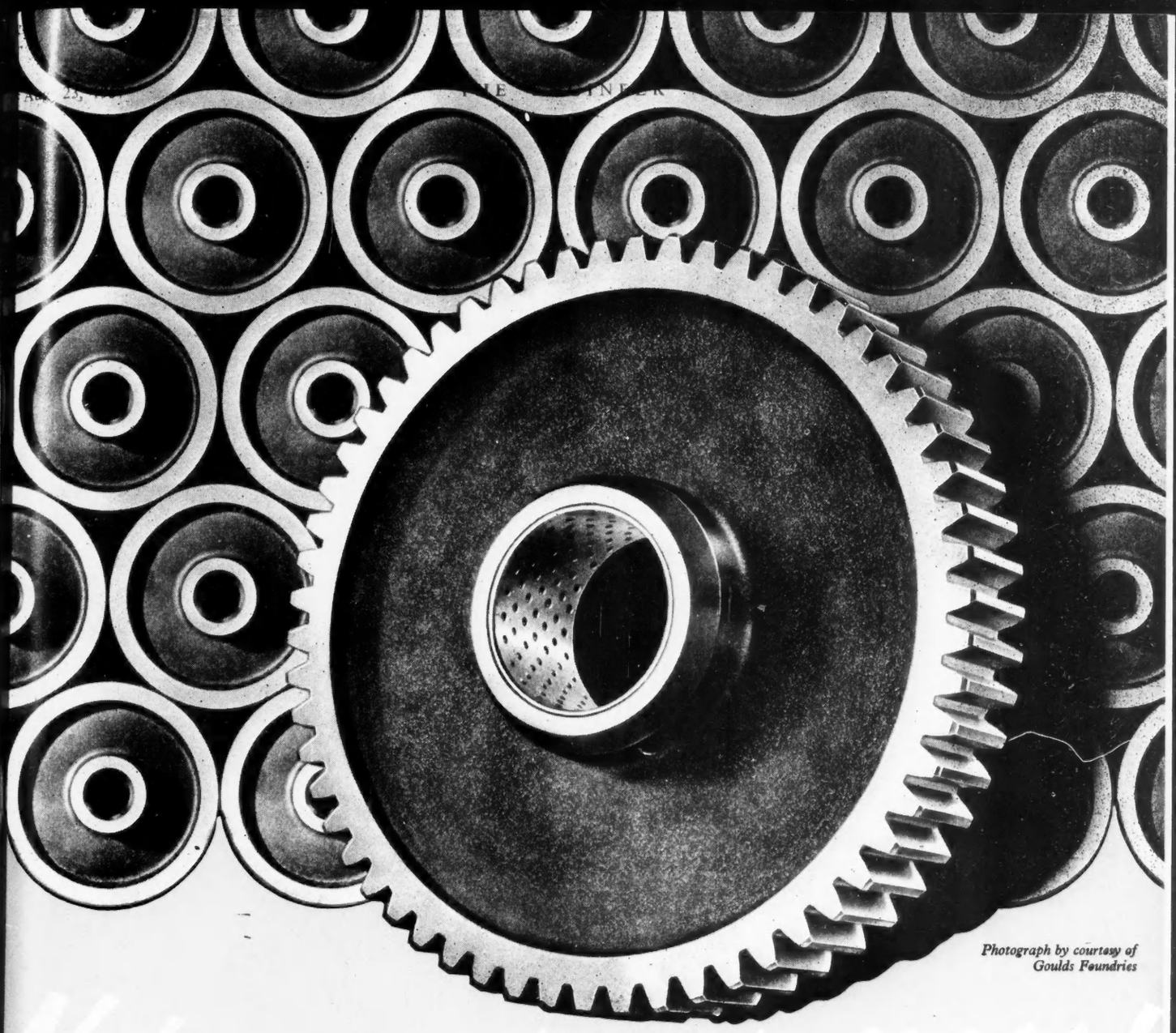

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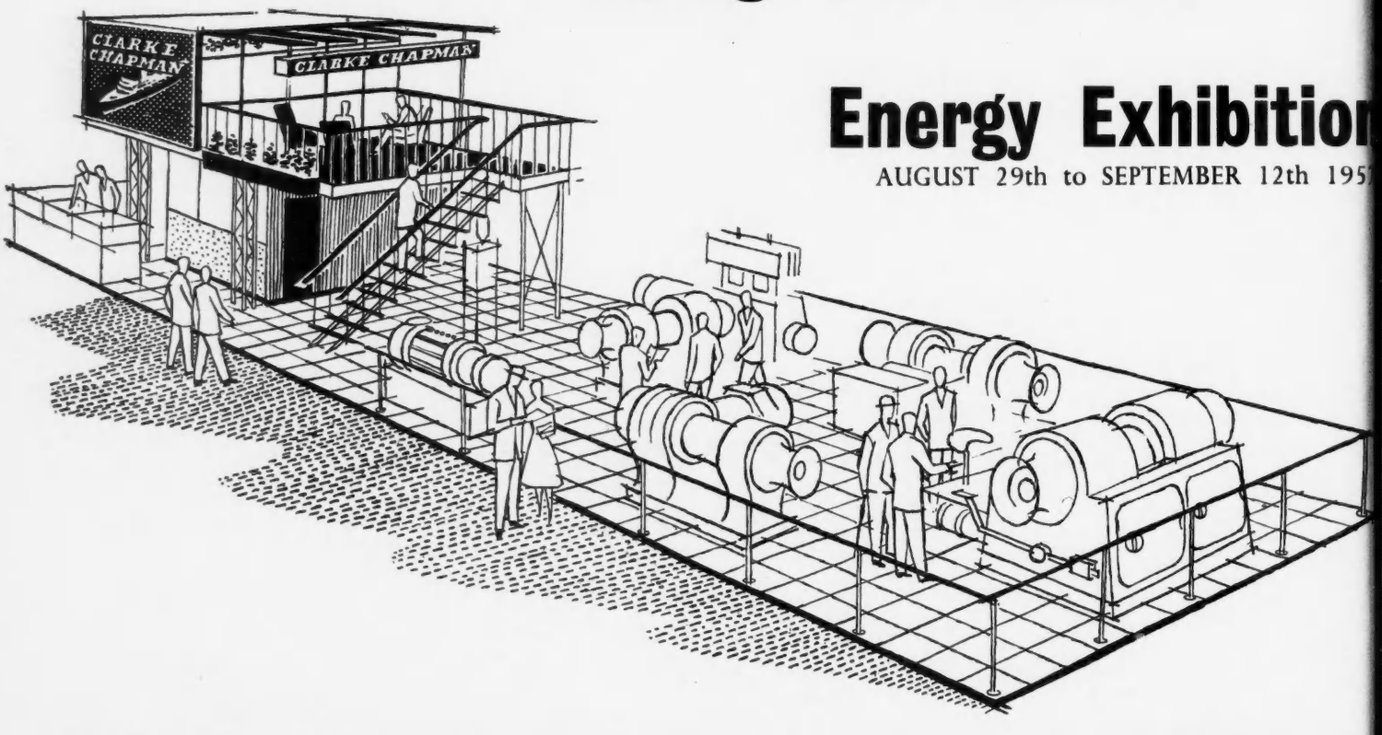

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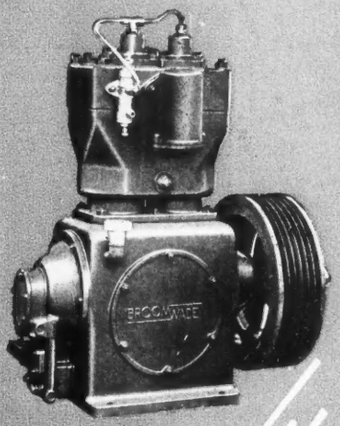

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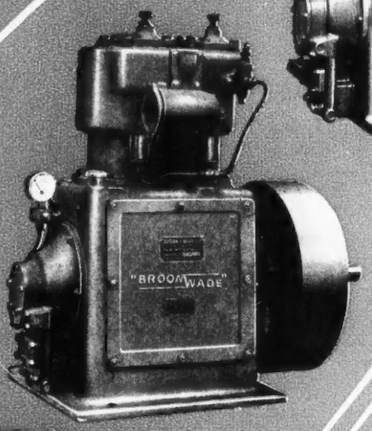

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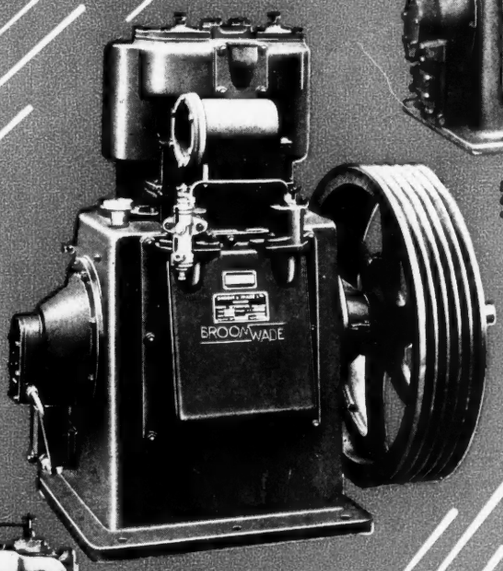

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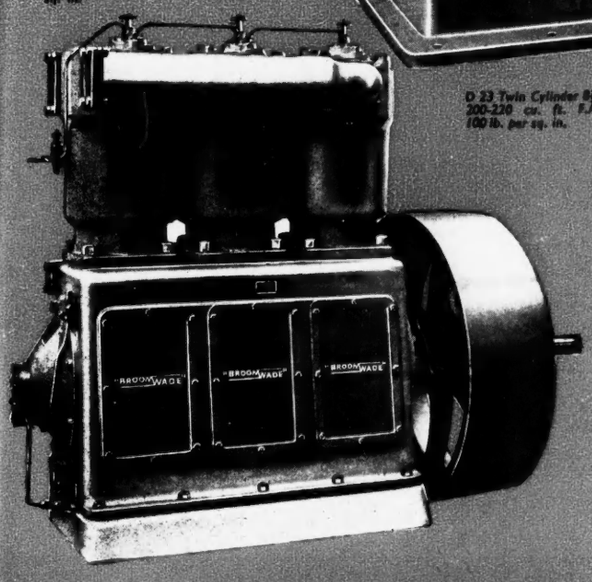

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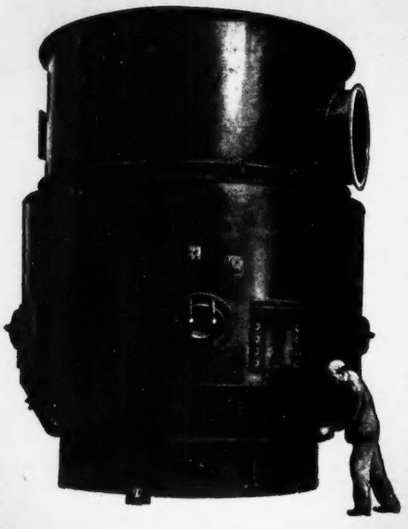

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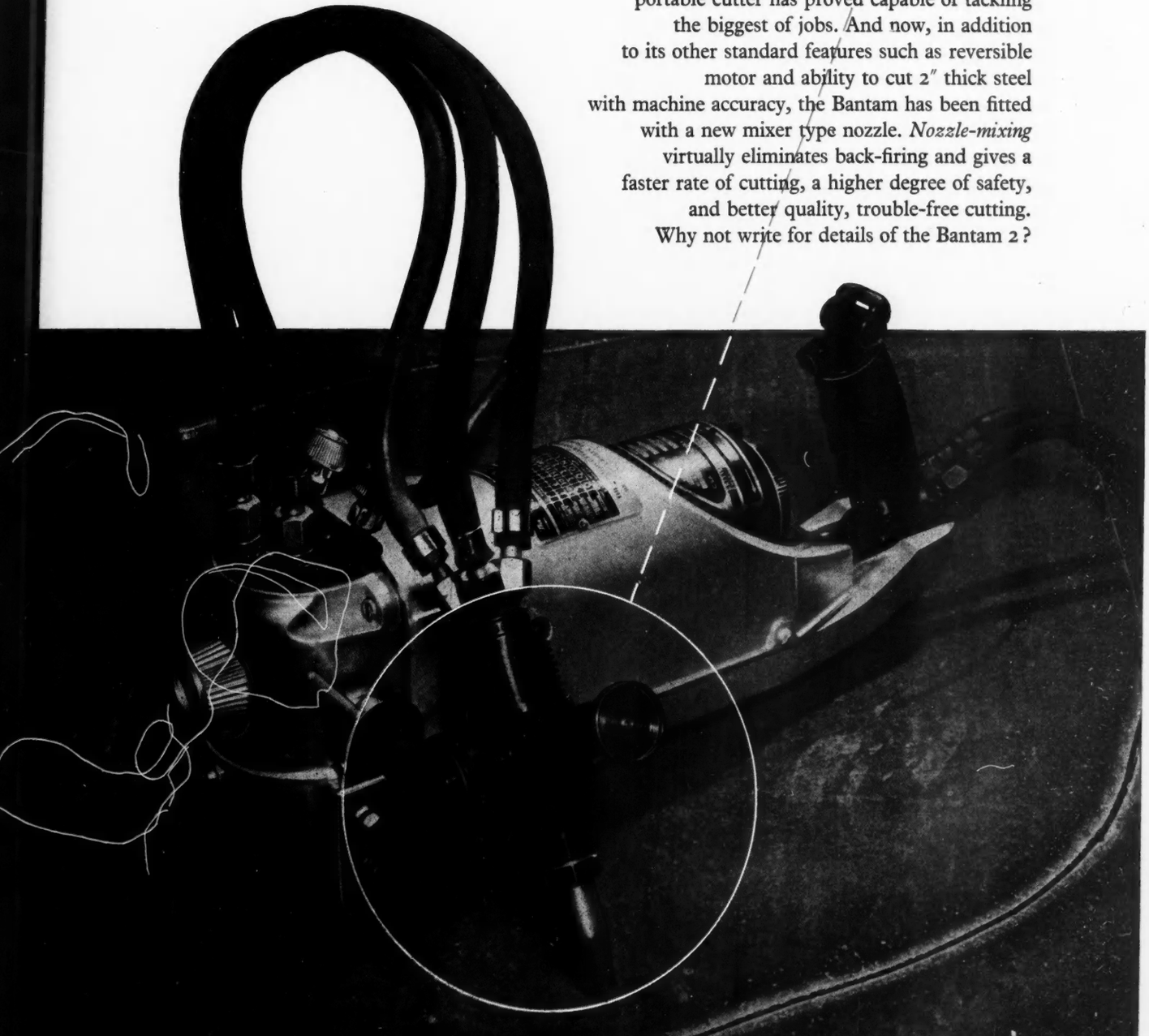

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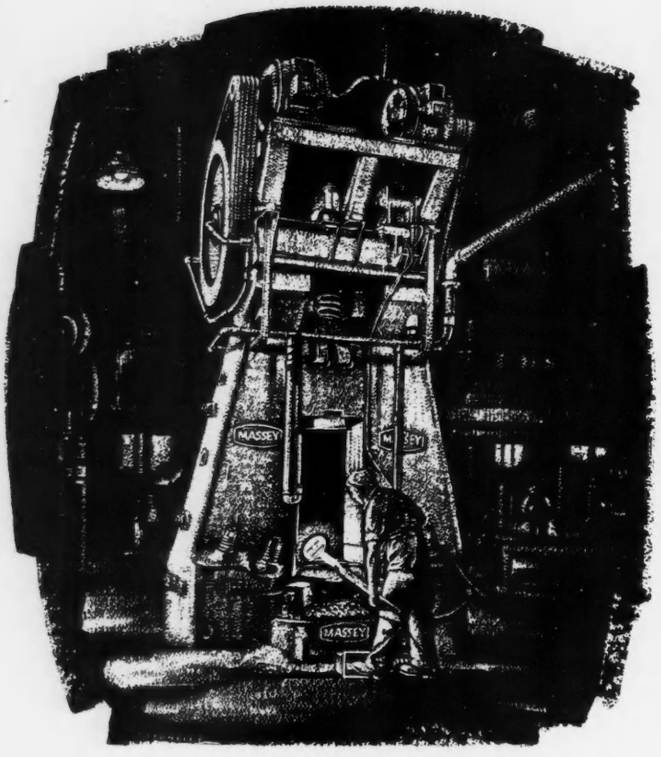

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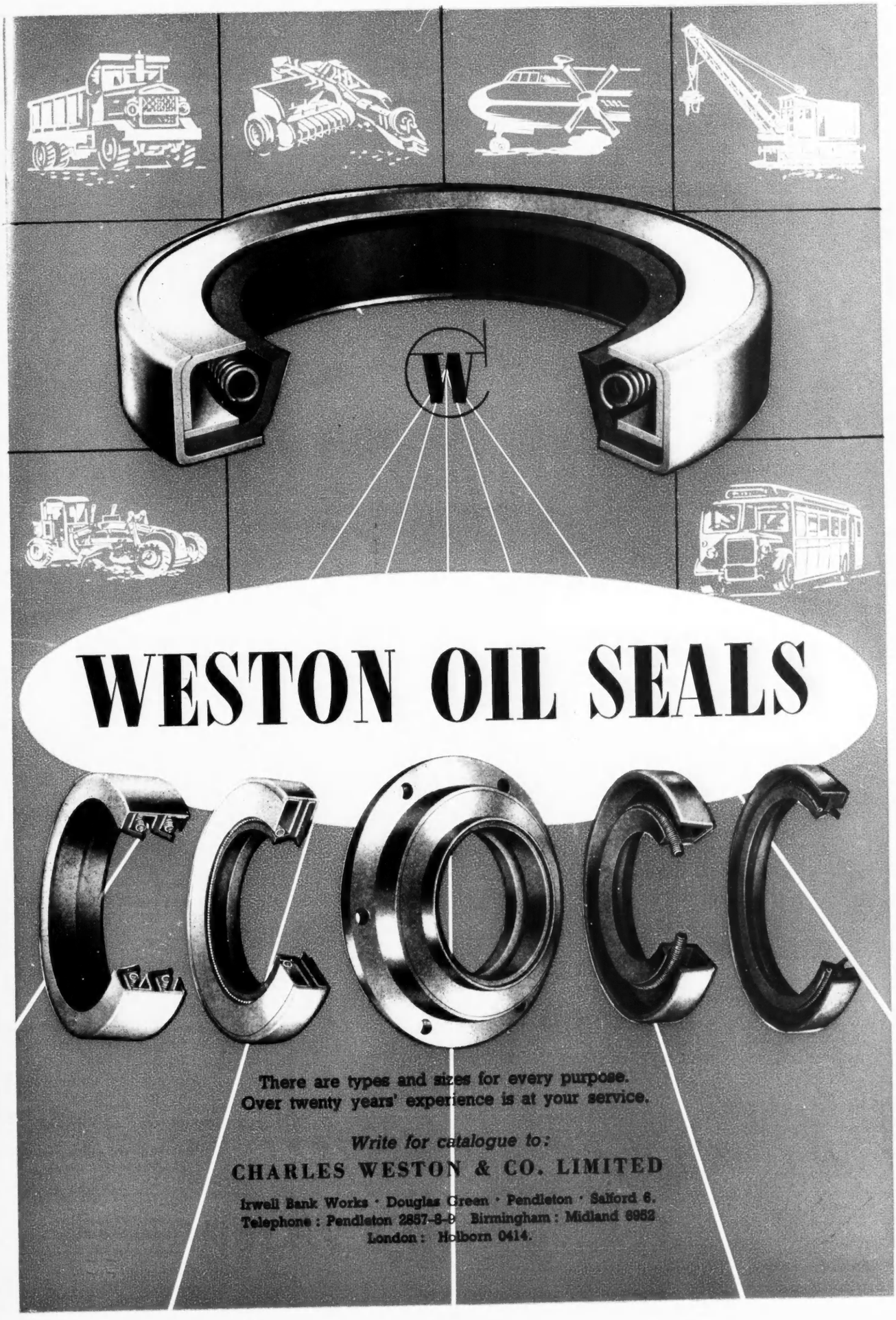
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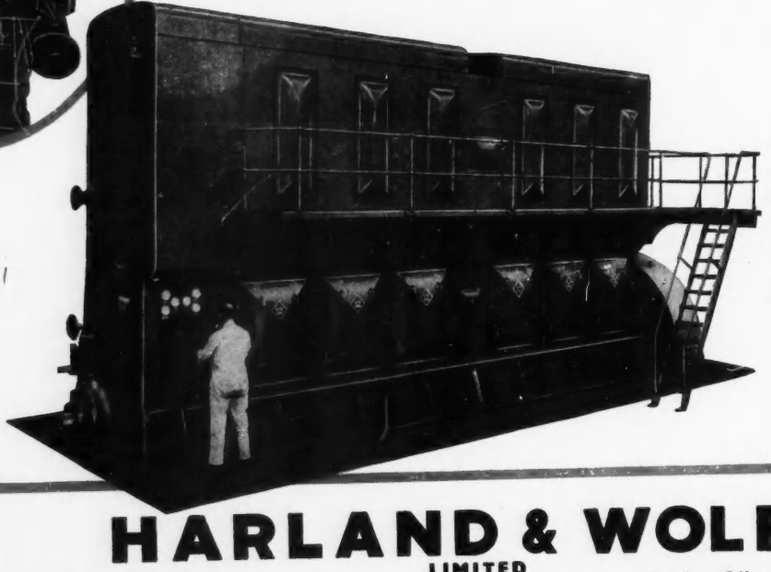

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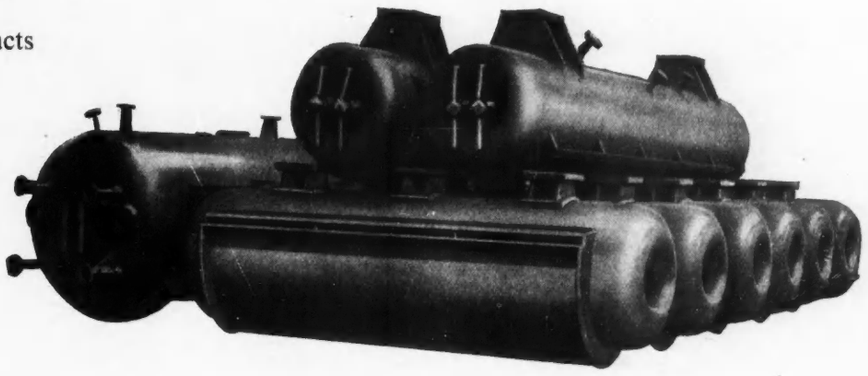

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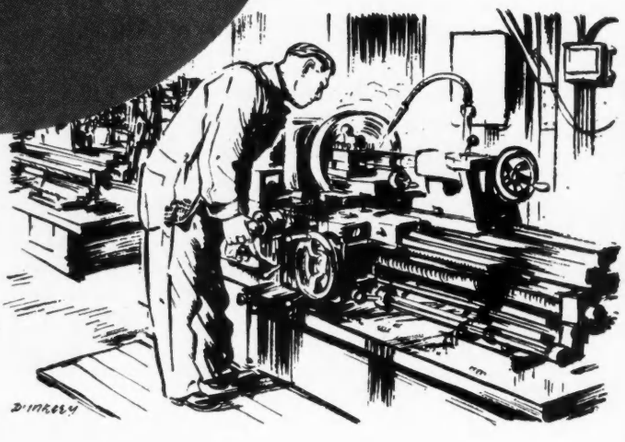

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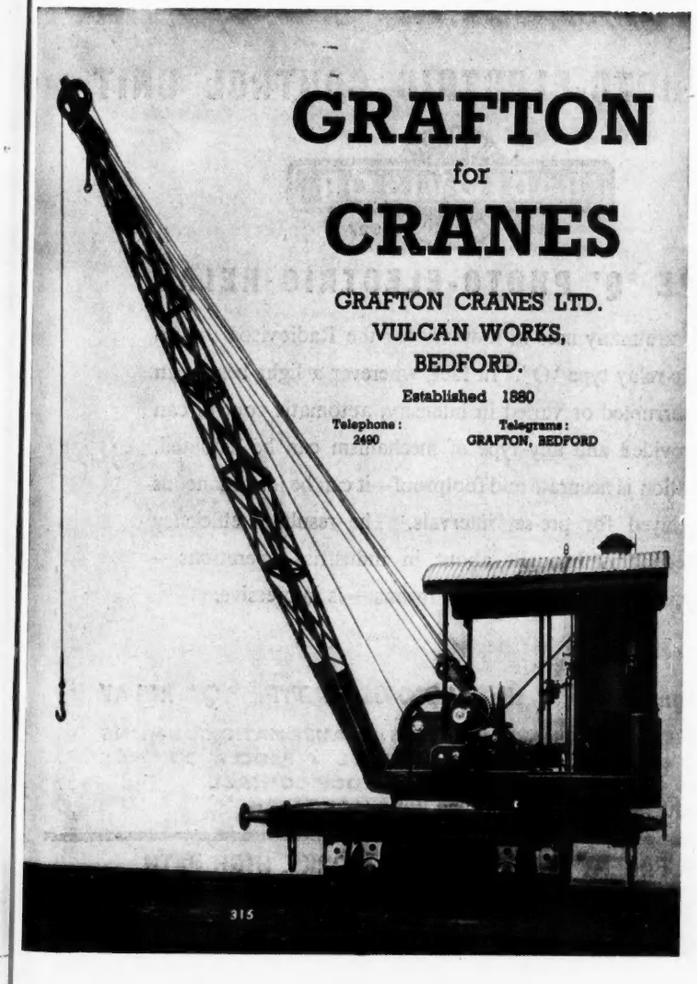

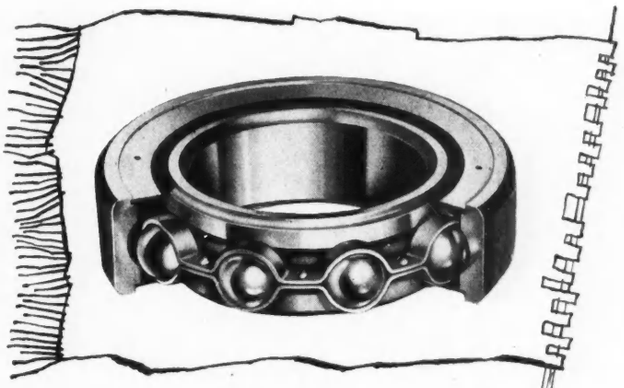

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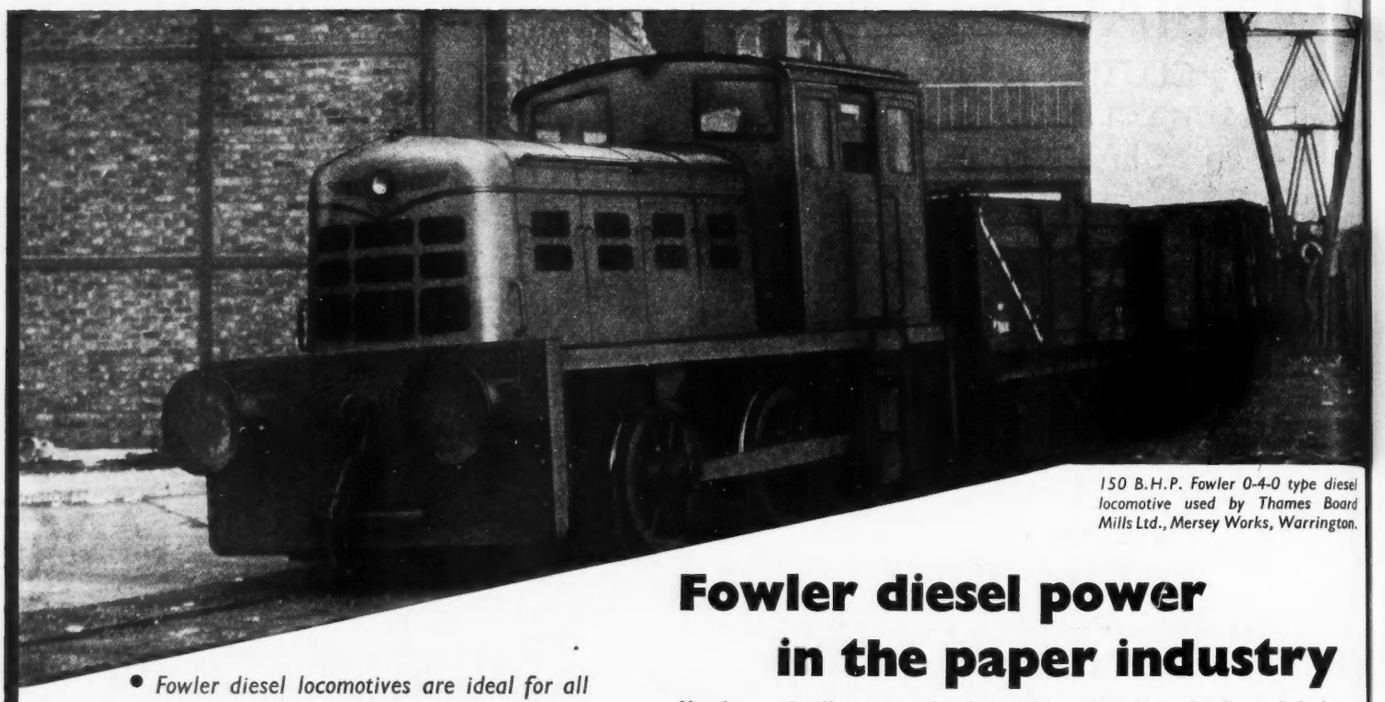

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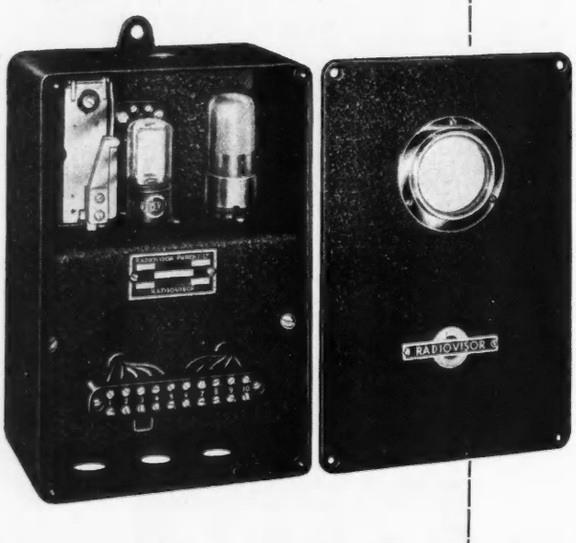

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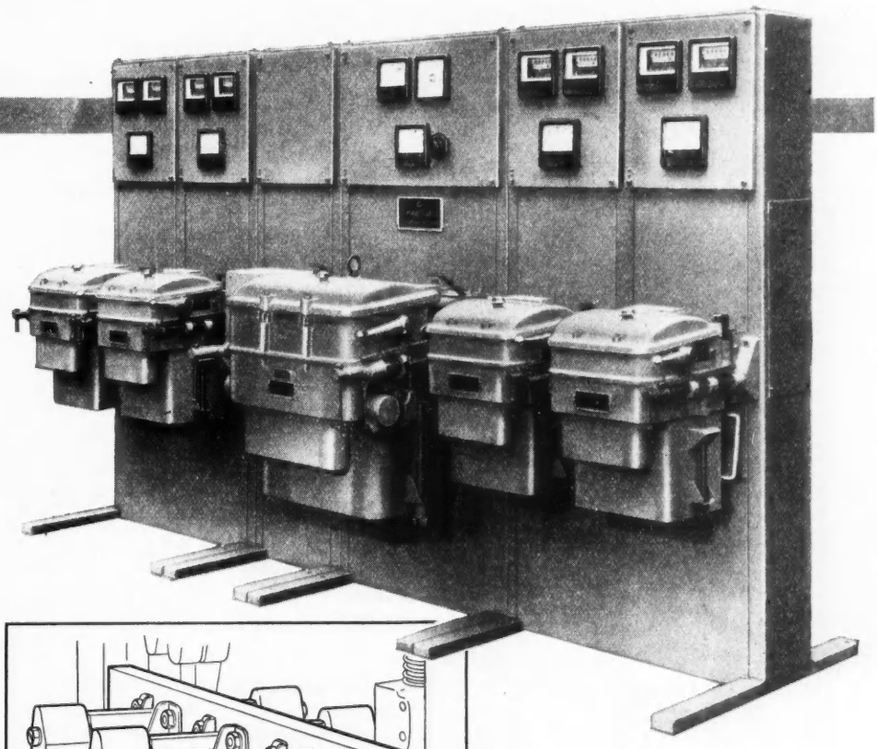

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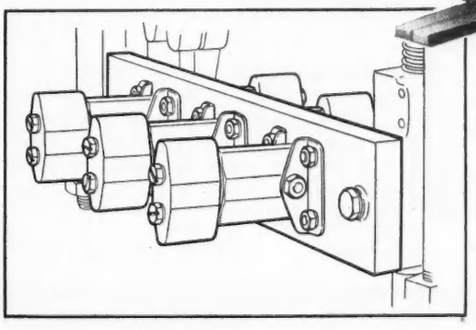

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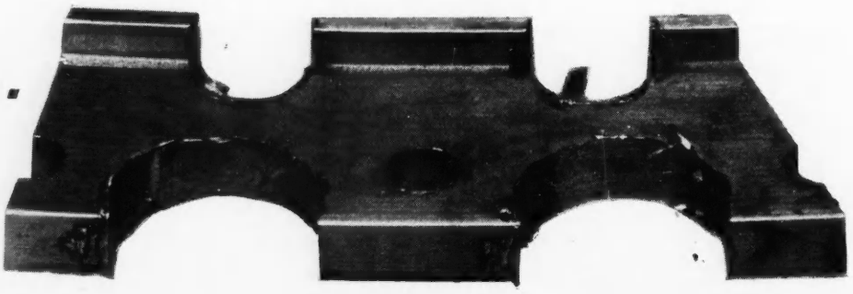

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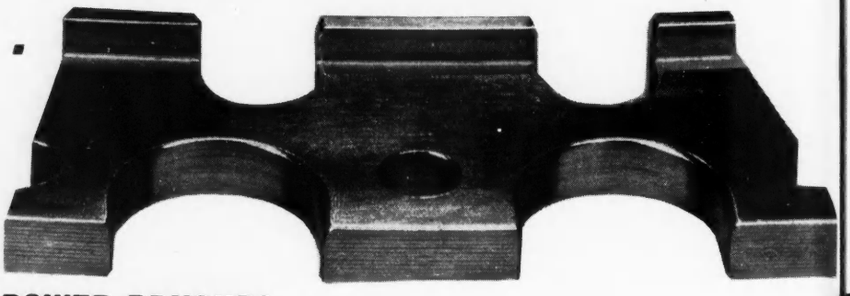

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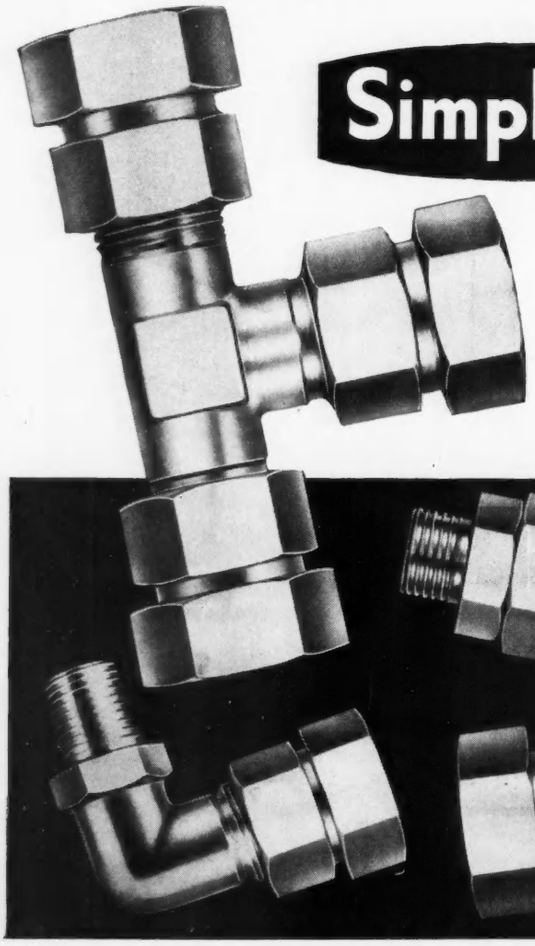

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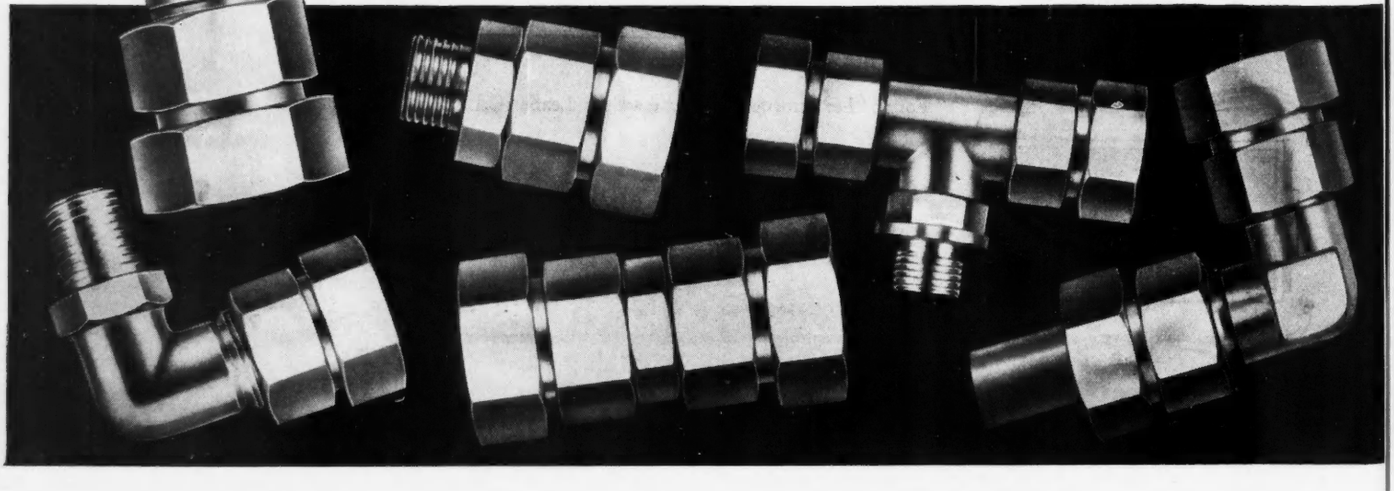

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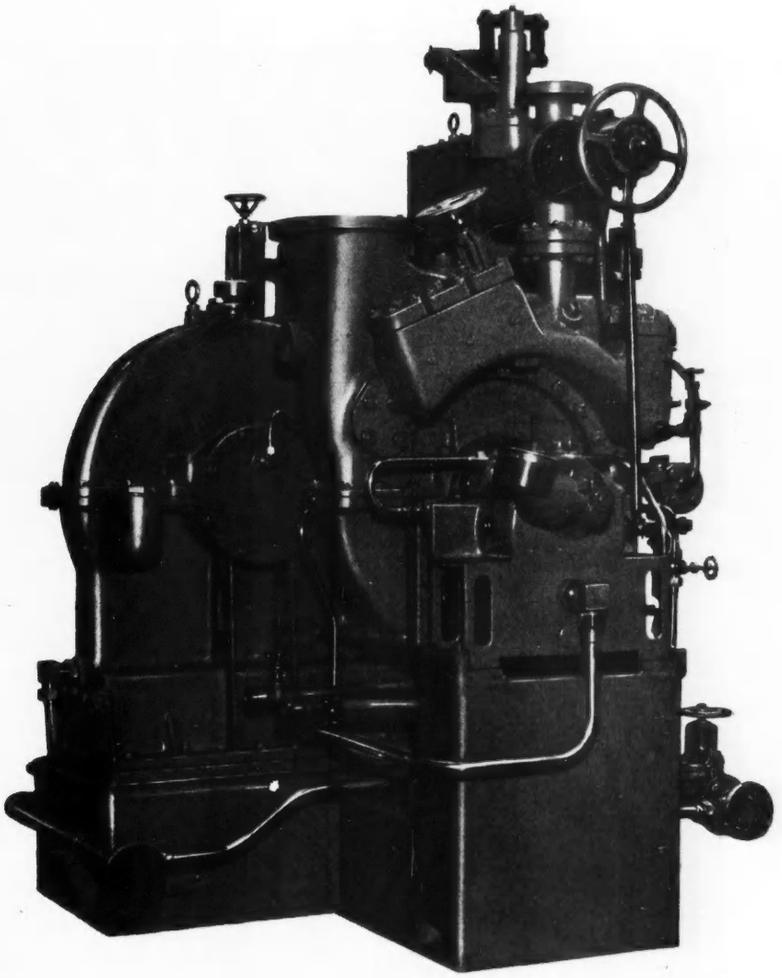

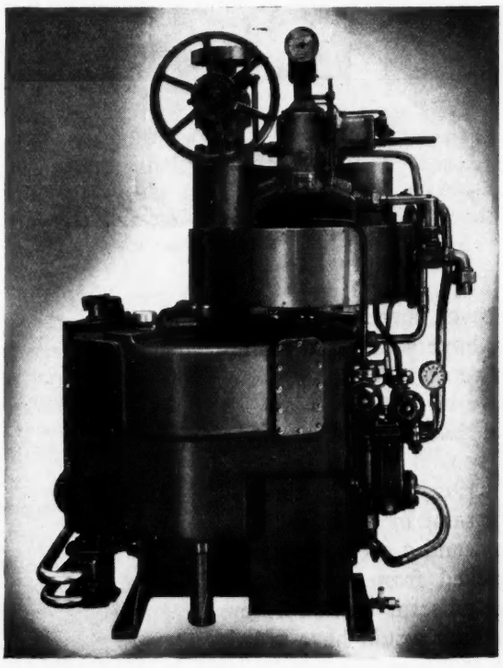

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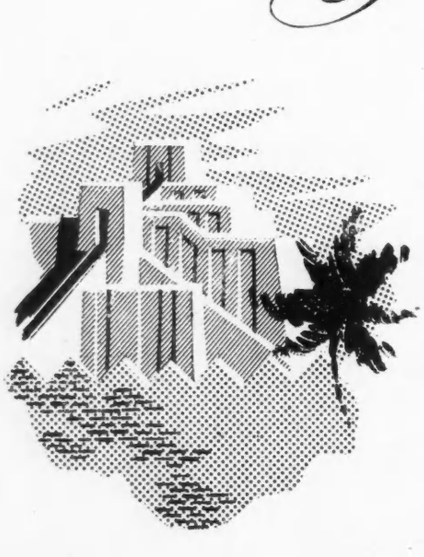

In a bas-relief found at Nineveh there is shown the transport on skids of a huge sculptured stone ; a horde of slaves pull on ropes while others assist with a large lever at the rear. The most interesting feature of the bas-relief, however, is the clear depiction of spoked wheels in the handcarts which are bringing up the tackle—wheels which appear to be the same in essential detail as the wheel of today, and a great advance on the solid disc hacked from a log. But the bearings on which the wheel is carried have developed in a fashion which would have greatly eased the labour of the slaves of Nineveh.

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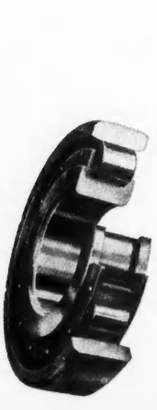

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THE ENGINEER

VOL. 204 No. 5300 AUGUST 23, 1957

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ON MAKING THE SEA FILTHY

We congratulate our contemporary, *Municipal Engineering*, upon again drawing attention to the practice of seaside towns of discharging untreated sewage into the sea and to the dangers involved. The leading article in that journal, a fortnight ago, drew particular attention to the possibility that there may be a connection between sea-bathing in polluted water and the incidence of poliomyelitis. Comment upon the article, we are particularly glad to note, has widened the discussion ; the general practice of seaside towns of discharging untreated sewage into the sea is being challenged. But what has surprised us in reading the discussion—in our contemporary, *The Times*, for example, which published a forthright leader on the matter—is the nature of the defence so far put up. The attitude of health officials and even of officials of the Ministry of Health appears to be that if a practice, for example the discharge of crude sewage into the sea, may be dangerous, but has not been proved to be dangerous, then there is no harm in continuing it. That view is precisely at variance with the idea of engineers that if a practice may be dangerous it should not be used publicly until it has been proved safe. But even if this strange doctrine of health officials were unequivocally acceptable, it is disquieting to contemplate large numbers of people bathing in waters contaminated by sewage ; and though we appreciate that the object of maceration—the only form of treatment adopted by many seaside places—is to make purification by the sea-water more rapid, that process may appear to the public a means of concealing from them the presence of the sewage !

No doubt the health officials' defence was put up because the original article in *Municipal Engineering* was concerned with the danger to health, not with amenity and decency. For there is a much more understandable defence available ; and for a small, more or less isolated seaside resort facing the open sea it may be a fully justified defence. It is a defence that can be put up to explain, though not to excuse, the equally filthy habit of polluting rivers. The sea, like a river, is capable of absorbing and purifying a limited inflow of sewage. Historically, therefore, when small seaside resorts discharged untreated sewage to the sea and inland villages discharged theirs to the local river no harm was done ; no nuisance was created, no amenity destroyed. But at some stage in the growth of a seaside resort or a village the nuisance does become apparent. What happened in the past was that a practice initially harmless became habitual and was continued often without a full realisation of what was happening. As the resort or village expanded into a town all that was done was to install and later to extend sewers. This historic development accounts, excusably, for the desperately polluted condition of many streams and rivers in this country to-day, for the partial pollution of many more, and for the threat that still more will become polluted. But inland, during the last hundred years, there has been growing appreciation of the danger. On the whole, further extension of pollution has been checked, and it may well be hoped that, through the work of River Boards and through the assistance of the Water Pollution Research Board and its work upon the treatment of "difficult" industrial effluents, it may begin soon to be reduced. Amongst industrialists, if less so amongst the public at large, of which local authorities are the representatives, there is, we think, growing appreciation that to pollute a river, to harm the interests of riparian owners downstream, to contaminate a real or potential source of water supply, and to destroy an amenity, is ethically indefensible ; and that even if the purification of an effluent is expensive, consumers of the goods manufactured ought to be prepared to pay for it. Certainly there is a much more general tendency nowadays than there used to be for effluent treatment to be studied, *ab initio*, when new factories are being laid out. But these remarks apply only to rivers ; not to estuaries or the open sea. There is still a tendency to take it for granted that if an untreated effluent is discharged sufficiently far out into salt water all requirements will have been satisfied. But in fact, when it is proposed to discharge an effluent to the sea,

investigation is needed to confirm that it will be satisfactory. The rate of outflow of raw sewage that sea-water can tolerate depends on a number of factors. In an estuary, for example, the same sea-water may oscillate back and forth with the tide and be replaced at a rate possibly not greatly higher than the rate of inflow of rivers discharging into it. Such water can be just as easily overloaded with sewage as river water, as is indeed demonstrated by conditions in the estuaries of the Thames, Tyne and Mersey, not to speak of others. Again, if the general sea-water flow is coastal, successive discharges along the coast can build up an intolerable accumulation of sewage in the water. But if the set of currents is seaward all may be well ; and it is unreasonable to assume necessarily that the discharge of crude effluent to the sea can never be satisfactory.

A hundred years ago the Thames as it flowed through London became an open, stinking sewer, before urgent action was taken to remedy the situation. It is devoutly to be hoped that before any such thing is allowed to happen to the sea alongside any of our seaboard towns they will awake to the danger and realise that, just as a river, if it is to remain healthy, can tolerate only a very limited inflow of sewage, so there are parts of the sea that can only tolerate a limited inflow. Unfortunately, the remedy is expensive. The sewers in seaboard towns have been, naturally, laid out to slope towards the sea. But available sites for sewage works usually lie only inland. If the sewage is to be treated it must therefore be pumped back to the works and perhaps the effluent must be pumped back again to the sea thereafter. It is understandable that seaside resorts should prove unwilling to incur the large expenditure involved. Yet, unless their trade is to suffer, it is obvious that the expenditure will have to be incurred sooner or later. The public will not for long be deceived by an argument that a practice, obviously filthy, can be tolerated on the grounds that there is no proof, statistical or other, that it is harmful to health !

JODRELL BANK RADIO TELESCOPE

In the third report of the Committee of Public Accounts, issued on Tuesday of last week, strong criticism was expressed about the cost of the Jodrell Bank radio telescope, which has just come into use by Manchester University. The cost was estimated at £335,450 in March, 1952, but has since risen to £700,000. The report contains the following remarks :— " It was stated in evidence that the engineering consultant changed the design without the concurrence of the University; new structural features were introduced into the instrument and the complexity and cost were thereby materially increased. Although the University professor who was primarily responsible for the outline design lived on the spot, he was not consulted so far as the Department* were aware " ; and " They [the committee] were particularly surprised to be told that the consulting engineers, before introducing substantial modifications in a novel and costly scientific instrument had not followed the common sense course of discussing their plans with the eminent scientist who was in charge of the project. Your Committee regard as highly unsatisfactory a state of affairs in which it was possible for the project to be altered substantially at greatly increased cost without the consent and approval of the Department or of the University or even of discussion with the scientist in charge." Both Professor Lovell, the " university professor " and " eminent scientist " referred to, and Mr. Husband, of the firm of consulting engineers, Husband and Co., responsible for the work, deny the truth of these statements. Though it would have been open to the Committee to call either of these two men before it, we understand that no evidence was in fact taken from them. Mr. Husband also categorically asserts that all changes of any importance or involving serious additional expenditure were discussed with Professor Lovell and all these discussions were confirmed in writing either by Professor Lovell or Mr. Husband. We understand that the whole of the correspondence in the matter has been handed over to Mr. Husband's legal advisers and that consideration is being given to the steps which can now be taken to correct what Mr. Husband asserts to be the erroneous impression created by the publication of the report. It is because legal action may be pending that we use such careful language about a matter on which our sympathies are obviously engaged upon the side of those who have brought a great engineering project of especial technical merit to fulfilment. Nor in these circumstances do we feel that it would be appropriate for us to comment as freely as in other circumstances we might have done. Only a few factual remarks appear to be called for. First, it should be noted that a major part of the additional cost of the telescope arose out of a decision to make the instrument operable upon the 21cm hydrogen spectral line wavelength, instead of wavelengths down to about 1m as originally intended, thereby greatly increasing the instrument's value. The stiffness of the structure had, in consequence, to be substantially increased. The present report remarks, presumably in relation to that decision, " In October 1955 . . . the University informed the Department orally that the increase was likely to be £240,000 and that it had become clear that the design had been changed substantially without the University's approval." Subsequently a Committee of Inquiry was set up jointly by the Department, the Nuffield Foundation (which contributed substantially to the cost of the project) and the University. The present report remarks upon the report of the Committee of Inquiry that it " recorded a very unsatisfactory position as between the University and their consultants." We now feel that the whole matter needs publicly to be cleared up. For to let matters rest as they are at present would be unfair to Professor Lovell and Mr. Husband, and must throw doubt upon the ability of the Committee of Public Accounts to do its job fairly.

* Department of Scientific and Industrial Research

The Engineer
100 Years Ago

(AUGUST 21, 1857)

" EUPHRATES AND TIGRIS "

" During the period of the Assyrian and Babylonian kingdoms there were not two rivers in the world which exemplified upon their surfaces and their banks more of the industry of man than the Euphrates and Tigris, and, with the exception of the Nile, none, perhaps, have yet stood upon a footing of equality with them ; while, at the present day there are not two rivers in the world whose industrial resources are so much neglected. . . .

" Can the waters of the Euphrates and Tigris, with the waters of their tributaries, be again used for irrigation purposes, and the fertility of the extensive country through which they flow be restored to what it was in the time of Herodotus ? To this question there is no doubt an affirmative answer may be safely given—a fact which ought to have considerable influence as to the line of the great trunk railway through Turkey to India. No doubt irrigation works would destroy the navigation of both rivers, but the loss thus sustained would be more than compensated for by the greater benefits gained by railway conveyance. The practical proposition, therefore, is the effect which a trunk railway through Turkey to India would have upon the agriculture of the provinces through which it would pass —a proposition, which of course, involves the effect which all the branch lines running into the trunk line would also have upon the agriculture of the districts through which they would pass. In other words, what effect would a proper system of Turkish railways have upon her agriculture? What effect would a proper system of railways have upon the agriculture of Asia ? "

AIRCRAFT FACTS AND FANCIES

We referred last week to the value of a basis of observed fact when decisions, irrevocable to a greater or less extent, are to be made, and welcomed the setting up of a body, the new Council on Prices, Productivity and Incomes, whose job, we took it, would be to give publicity to facts and the deductions to be drawn from them. It follows from our desire to have the facts that, though we should like to do so, we cannot assign much weight to the report of the special committee appointed by the Air League of the British Empire to study the organisation, equipment and functioning of British civil air transport. The report is unquestionably valuable where it draws wider attention to such a fact as that the capacity of scheduled international flights is determined by international

negotiation and not by the operator. It is useful when it draws attention to the possibility that fast transport may be more economic than cheap transport for maintaining such a user as an Army. But the intensive array of evidence necessary to support some of the committee's conclusions is absent. In a discussion of Atlantic services for instance, there is no mention of the unsuccessful transatlantic services of British South American Airways and of Airwork; and the sole reason discussed for the use of obsolescent aircraft by independent operators in this country is that of financial difficulties. It is disquieting also to a critic that the committee does not mention that a diagram reproduced from an unnamed source contains certain errors. It is recommended that this country's air transport be handled jointly by publicly and privately owned lines. But once air transport has reached a stage at which a commercial organisation can conduct it, it becomes a matter of choice rather than of necessity whether there should be a nationalised operator and although it is pointed out that there are many examples of nationalised air lines to study, the committee does not examine them to see whether there is any essential need for such a line in, say, France, where independent air lines are prospering. Rightly, the committee draws attention to the need now to start work upon developing civil aircraft for a period beyond the more immediate future. But in advancing specifications for particular aircraft needed in the future the committee picks upon a somewhat peculiar one. It is for a machine with greater gross weight and passenger capacity than a "Britannia," vertical take-off capability, and a London–New York journey time of two and a half hours. This provides a delightful combination of virtues. But it would seem to belie the oft-heard assertions that the supersonic civil aircraft is "difficult" in such respects as lift-drag ratios and dead weight. Had the body of the report been composed of a closely reasoned survey of objective evidence leading to the conclusions drawn, we should have greeted it cordially: for we should greatly welcome authoritative support for such of the Committee's recommendations as a proving unit to carry out the preliminary route trials and prepare proved performance figures, in the manner of motor vehicle research and the National Institute of Agricultural Engineering, and of a Ministry charged to develop and encourage British aviation, rather than one devoted to regulating and restricting it as part only of its duties. But in reality the report enshrines little more than opinions. Those opinions may indeed be sound, and we think many of them are sound. But such facts as are given in the report are not in our opinion sufficient, alone, to support them.

A Seven Day Journal

The Future of British Air Transport

THE report was published last week of the committee set up in April this year by the Air League of the British Empire to study the organisation, equipment and functioning of British civil air transport. The committee, under the chairmanship of Sir Miles Thomas, D.F.C., consulted a wide range of authorities, including military and civil operators, aircraft manufacturers and economists. It concluded that, unless the present slow decline in Britain's share of air traffic accelerates, the capacity needed will double in each of the next two periods of five years. Further expansion of the two national corporations, it believes, would not increase their efficiency, and it proposes that independent companies take a share in the traffic; since some of the expansion will be at the expense of shipping, the shipping lines might be expected to invest in air transport. The independent and national lines should be unified so far as the passenger was concerned.

The committee observed that it was necessary for the national economy as well as prestige that this country should build aircraft to rival in performance foreign machines; they indicated two projects that appeared feasible and attractive, a very large 500 m.p.h. cargo aircraft and a supersonic airliner capable of operating off small airfields. To support the industry in such expensive undertakings there should be a Government-sponsored proving unit to carry out development flying; the Government should also adopt air movement to supply and maintain the Armed Forces overseas. The main policy recommendation is that there should be a Minister charged, not to restrict and regulate air transport, but to encourage it; under him there should be a licensing board, comparable to the Civil Aeronautics Board of the United States, having jurisdiction over the air carriers and apportioning scheduled services.

Government Research

THE Department of Scientific and Industrial Research has published its report for the year 1955–56, and we commented in a leading article last week on the proposed changes from direction by an advisory council to a "research council," and other general matters. The report states that during the year the D.S.I.R. incurred a net expenditure of nearly £6,500,000 and employed a staff numbering roughly 4500; the estimate for expenditure in the year ended March 31, 1957, is about £1,000,000 greater than the figure just given.

The report covers the activities of fifteen research establishments and about fifty associations. A great deal of the work which these various bodies have in progress bears, more or less directly, on engineering. There is much of great interest recorded in the report, and researches of all kinds are evidently being pushed along with commendable vigour. Not all research involves the application of abstruse theory, and the practical results achieved are sometimes surprising. To give one example, taps giving a spray instead of a continuous stream of water were fitted to the basins in an office building. It is stated that such taps were more hygienic and acceptable to the staff and they halved the fuel bill for hot water.

The advisory council visited three D.S.I.R. establishments during the year. It was particularly impressed with the work done by the Water Pollution Research Laboratory, in collaboration with the Port of London Authority, in surveying the effects of pollution in the River Thames. The Road Research Laboratory is commended for the vigour with which its large programme of work, covering road construction, traffic flow and road safety, is conducted and its results disseminated. The Chemical Research Laboratory is undertaking research on selected topics of national interest, such as corrosion, which are not being done either by Universities or industry. The Council was impressed by the quality of much of the work but realised that not everything that is desirable could be undertaken at once, and that very careful selection of topics is essential.

Other matters of special interest include the discovery of a correlation between mortality and the degree of atmospheric pollution during persistent fog, the advancement of research on the hydrogen-oxygen fuel cell to the stage of industrial development, progress in the continuous casting of steel, and the development of a "fluid bed" technique in the textile industry.

Two Sites for Nuclear Power Stations

THE Central Electricity Authority has announced its intention to apply for consent to develop its fourth nuclear power station at Trawsfynydd, Merionethshire, in the Snowdon National Park. The Minister of Power and the local planning authority are to be approached shortly. The Authority has also expressed its interest in a site at Edern, Caernarvonshire, which it has concluded is suitable for a larger nuclear power station than is planned for Trawsfynydd.

The Trawsfynydd site is on the northern shore of an artificial lake that was created about thirty years ago to store water for the Maentwrog hydro-electric power station. The lake is big enough to provide cooling water for a nuclear power station of up to 500MW. It is stated that the land, which is owned by the Authority, is rocky and broken and of no agricultural value. The reactors can be founded directly upon rock. A station of 400MW to 500MW is proposed for Trawsfynydd, connected by overhead line to the 275kV transmission system at the Ffestiniog pumped storage station some 5 miles to the north, construction of which is just starting. Under this scheme the Trawsfynydd station would be brought into service in 1962.

The Edern site is about 2 miles west of Edern village, and is on the north coast of the Lleyn Peninsula. It is said to consist of rough heathland and low cliffs which, after excavation, would provide a rock foundation for the reactors. Unlimited cooling water is available from the sea.

Collaboration with Norway on Nuclear Energy

THE U.K. Atomic Energy Authority has agreed to co-operate with the Norwegian Institute for Atomic Energy in the Halden reactor project. The project concerns an experimental reactor designed to produce process steam for wood pulp mills, &c. Operation is scheduled to start early next year. There is to be collaboration between the Norwegian Institute and the U.K. Authority in the development of fuel elements for later charges, and in the meantime the initial charge of uranium elements is to be supplied by the Authority. Design and operating experience obtained in the experiment will be shared with the Authority.

Supporting Skirts for Reactor Pressure Vessels

By RAYMOND HICKS, Ph.D.*

This article deals with one of the structural engineering problems encountered during the design of the reactor pressure vessel for the nuclear power station to be built for the South of Scotland Electricity Board. It is shown how a general solution was obtained to give the moments and shear forces induced in the vessel and its supporting skirt due to the various types of loading imposed on the structure during fabrication and full operating conditions.

WHILE it is realised that codes of practice and specifications are the product of long and careful deliberation, conservatively based on experience in service, it will be appreciated that in the case of reactor pressure vessels the plate thickness, vessel diameters, and operating conditions are different from those envisaged by the authors of the existing codes of practice and specifications. It is necessary, therefore, when designing a reactor pressure vessel, to analyse as completely as possible the distribution of stress in the structure. Thus, as well as satisfying the conditions imposed by B.S. 1500, the British Standard specification for fusion welded pressure vessels, the structure can be designed so that the bending stresses induced in the vessel due to the constraining effect of the skirt are as low as is practically possible.

The need to keep the bending stresses low is apparent when one considers that structural failures have occurred due to excessive bending stresses at points of discontinuity, because induced bending stresses can produce the local plastic deformation necessary to initiate a brittle fracture crack. For example, there was the failure of a spherical pressure vessel in Morgantown, U.S.A., in 1944[1] when the bottom dropped out of the sphere while under test. Failure was due to brittle fracture, which produced a tear 350ft long, only 4ft of which followed a welded seam. The direction of the herringbone indicated that the tear probably started at a point just below where a column was attached to the shell. Subsequent strain gauge readings on a duplicate sphere indicated high local stresses at column attachments. Finally, as a result of a strain-gauge investigation into the stresses in a spherical vessel designed to A.S.T.M. standards, it was found that at the column support the measured stress was 2·88 times that predicted by simple theory.

Vessel Support

The choice of a supporting means for a reactor pressure vessel and its core leads to a comparison between (*a*) a continuous skirt support such as a cylinder or cone and (*b*) a discontinuous support similar to the "A" frames used on the Calder Hall reactors.

The effect of supporting a spherical vessel and its core on continuous skirt supports, one of which is located inside the vessel, and the other directly underneath on the outside, as shown in Fig. 1, is to induce in the skirts and loaded vessel a system of bending and shear stresses due to the constraining effect of the skirts. The magnitude of these stresses depends on the relative thicknesses of the components of the structure joined at the discontinuity as well as the pressure in the vessel, the weight of the core, and any temperature variations in the structure in the region of the discontinuity.

For the design of the G.E.C./Simon-Carves reactor pressure vessel, a detailed stress analysis was made for the supporting means and it was found that by suitably choosing the thicknesses of the inner and outer skirts, the bending stresses induced in the structure could be kept relatively low so that the sum of the membrane and bending stresses in the vessel and skirt at the point of support was everywhere less than a quarter of the ultimate tensile stress for the material.

Basically, the analysis of the skirt problem reduces to the finding of the four unknown bending moments and four unknown shear forces induced in the four components of the structure meeting at the discontinuity. This involves the solution of eight simultaneous equations which, in the analysis described here, was done generally to give expressions for the induced stresses in terms of the five dimensional variables :

(i) thickness of vessel ;
(ii) thickness of outer skirt ;
(iii) thickness of inner skirt ;
(iv) diameter of sphere ;
(v) diameter of cylindrical skirts.

For design purposes this general solution was used to find expressions for the stress distribution induced in the vessel and its skirts due to the following load systems :

(i) a uniform radial pressure inside the vessel ;
(ii) an axial load applied to the inner skirt ;
(iii) an axial load on the outer skirt due to the dead weight of the vessel ;
(iv) an axial load carried externally by the vessel ;
(v) an axial temperature gradient in the outer skirt.

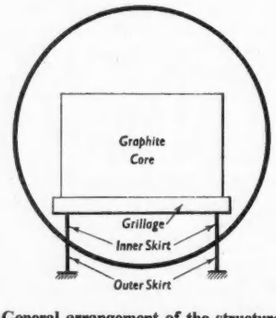

Fig. 1—General arrangement of the structure showing the location of the inner and outer skirts

To obtain general solutions for the five types of loading specified above, it was necessary to determine forty functions defining the moments and shear forces induced in the structure at the point of support. These functions were all obtained in the following form :—

$$\text{Moment (or shear force)} = C.F(r)$$

where C is a constant and $F(r)$ a function of the dimensions of the structure.

For example, due to an internal pressure p, the moment induced in the bottom section of the vessel is given by

$$M_{VT}=\frac{p(1-\nu)R_V^2K}{4\beta^4}\left\{\left(1-\frac{t_{SB}^2}{t_{ST}^2}\right)\left[1-\frac{4t_V^3}{t_{ST}^3}-\frac{t_{SB}^2}{t_{ST}^2}\right]-2\left(1+\frac{t_{SB}^{3/2}}{t_{ST}^{3/2}}\right)\left[1+\frac{t_{SB}^{5/2}}{t_{ST}^{5/2}}+\frac{2t_V^{5/2}R_S^{1/2}}{t_{ST}^{5/2}R_V^{1/2}}\right]\right\}$$

where

R_V = radius of vessel
R_S = radius of skirt
t_V = thickness of vessel
t_{SB} = thickness of outer skirt
t_{ST} = thickness of inner skirt
ν = Poisson's ratio

$$\beta^4=3(1-\nu^2)\frac{R_V^2}{t_V^2}$$

and

$$\frac{1}{K}=2\left(1+\frac{t_{SB}^{5/2}}{t_{ST}^{5/2}}+\frac{2R_S^{1/2}t_V^{5/2}}{R_V^{1/2}t_{ST}^{5/2}}\right)\left(1+\frac{t_{SB}^{3/2}}{t_{ST}^{3/2}}+\frac{2R_V^{1/2}t_V^{3/2}}{R_S^{1/2}t_{ST}^{3/2}}\right)-\left(1-\frac{t_{SB}^2}{t_{ST}^2}\right)^2$$

While it is outside the scope of this article to tabulate the forty functions which completely determine the induced moments and shear forces for the five types of loading given above, it may be of interest to note that they are given in the full structural analysis to be published by the Institution of Mechanical Engineers. Furthermore, at a later date, it is hoped to publish a series of curves which give directly to the pressure vessel designer values of $F(r)$ for a wide range of the dimensionless ratios appearing in the above expressions.

Method of Analysis

A method for analysing the induced bending and shear stresses in a symmetrically loaded shell of revolution was developed in 1912 by H. Reissner.[2] This method was generalised and applied to particular cases by E. Meissner[3] who obtained a solution to the basic differential equations in the form of a hypergeometrical series. For a spherical shell, he found that the convergence of this series becomes slower as the ratio of the diameter of the sphere to its thickness increases, so that for large values of the ratio this method of solution is of little practical use. For example, Ekström[4] has shown that when the ratio is 62·5 it is necessary to consider not less than eighteen terms in the series.

An approximate solution to the problem has been obtained by J. W. Geckeler[5], who made the simplifying assumption that in the region of the induced moments and shear forces, the shell of revolution can be replaced by an equivalent cylinder. This implies that for the case of, say, a spherical pressure vessel, Geckeler's solution is applicable only when the supporting skirt is attached to the vessel at or near its equator.

A better approximation, and the one often used in practice, was obtained by Hetényi[6] in 1938. This approximation is equivalent to assuming that in the region of the vessel where the induced stresses are relatively large, the vessel can be replaced by an equivalent conical section, because the meridianal length of such a region is small compared with the radius of curvature of the vessel at the point considered. As an example, Hetényi considered the case of an axially loaded spherical cap with a rigid boundary support. He showed by direct comparison (reference 7 page 475) that when the shell thickness is relatively small, the approximate values for the induced bending moments and

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shear forces are in close agreement with those predicted by the exact theory.

A comprehensive study of the bending of cylinders under the action of axial symmetrical loading is given by Hetényi[8] in his book dealing with beams on elastic foundations. He shows that the induced bending stresses are confined to a region within close proximity to the point of application of the load, so that, except for very short skirts, the length of the skirt has no effect on the magnitude of the induced stresses. Hetényi also showed that for practical shells the membrane stresses have a negligible effect on the induced stresses. That is, one can determine the displacements due to membrane stresses and calculate the corresponding bending and shear stresses necessary to maintain compatibility. The total stress is then obtained by simple addition, since Hetényi's results imply that the principle of superposition is applicable in the case of shells under the combined action of bending and membrane stresses.

For the particular class of pressure vessels covered by the general solution described here, the ratio R_V/t_V is assumed sufficiently large to justify using Hetényi's solution when evaluating the bending moments and shear forces induced in the structure. Furthermore, the ratio of skirt length to skirt thickness is assumed large so that the effective skirt length can be taken as infinite when considering its constraining effect on the vessel. The first of the assumptions is virtually always satisfied when dealing with large diameter pressure vessels, while the second assumption can be verified for any particular problem.

To obtain the general solution for the moments and shear forces induced in the four components of the structure meeting at the discontinuity, use was made of the following known expressions for the horizontal radial

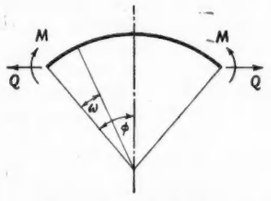

Fig. 2—Symmetrically loaded spherical cap

displacements and tangential end rotations of the spherical cap shown in Fig. 2 (see, for example, references 6 and 9).

$$\Delta_V=\frac{Q\beta R_V\sin\phi}{Et_V}\left(K_2+\frac{1}{K_1}\right)+\frac{2M\beta^2\sin\phi}{Et_VK_1}$$

$$\theta_V=\frac{2Q\beta^2\sin\phi}{Et_VK_1}+\frac{4M\beta^3}{Et_VR_VK_1}$$

where

$$K_1=1-\frac{(1-2\nu)}{2\beta}\cot(\phi-\omega)$$

$$K_2=1-\frac{(1+2\nu)}{2\beta}\cot(\phi-\omega)$$

It can be verified that at the free edge of the cap K_1 and K_2 can be taken as unity when R_V/t_V is large and ϕ has practical values. This implies that a moment M_E per unit length applied externally to the sphere at its point of support is distributed equally between the top and bottom portions of the sphere; furthermore, the corresponding induced shear forces are equal in magnitude and act in opposing directions. Similarly, a shear force Q_E per unit length applied externally to the sphere at its point of support is distributed equally between the top and bottom portions of the sphere, while the corresponding induced moments are equal in magnitude and act in opposing directions. Alternatively, it can be stated that when K_1 and K_2 can be taken as unity, an external moment acting uniformly around the sphere at its point of support produces a tangential rotation with no accompanying radial displacement, while a corresponding external shear force produces a radial displacement with no accompanying rotation.

Finally, to obtain a general solution, use was made of the following well-known expressions for the radial displacement and tangential rotations of an end loaded cylinder.

$$\Delta_C=\frac{Q}{2D\lambda^3}+\frac{M}{2D\lambda^2}$$

$$\theta_C=\frac{Q}{2D\lambda^2}+\frac{M}{D\lambda}$$

where D and λ are constants defined by

$$D=\frac{Et^3}{12(1-\nu^2)}$$

$$\lambda^3=\frac{3(1-\nu^2)}{R^2t^2}$$

Using the basic relationships given above, a system of equations was obtained for the boundary conditions at the junction of the vessel and skirts. These equations correspond to the equilibrium and compatibility conditions at the discontinuity and can be written as follows:

$$M_{VT}+M_{VB}=M_{EV}$$
$$Q_{VT}+Q_{VB}=Q_{EV}$$
$$M_{ST}+M_{SB}=M_{ES}$$
$$Q_{ST}+Q_{SB}=Q_{ES}$$
$$M_{EV}=M_{ES}$$
$$Q_{ES}=Q_{EV}$$
$$\theta_{ST}=\theta_{SB}=\theta_{VT}=\theta_{VB}$$
$$\Delta_{ST}=\Delta_{SB}=\Delta_{VT}=\Delta_{VB}$$

where the suffixes indicate the top section of the vessel (VT), the bottom section of the vessel (VB), the top skirt (ST), and the bottom skirt (SB), while (EV) and (ES) show that the moments and shear forces act externally on the vessel and skirts due to their interaction.

During the general solution of this problem, it was found that the above set of equations reduced fairly easily by elimination to a corresponding system of four equations with four unknowns, while the solution of the reduced set of four equations involved a great deal of algebraic manipulation before the final expressions for the induced moments and shear forces were obtained.

Heat Exchangers

In contrast to the large number of simultaneous equations associated with the method of solution used for the reactor pressure vessel, it was found that the corresponding analysis for the induced stresses in the cylindrical heat exchanger and its skirt reduced to the solution of two simultaneous equations. This reduction in the number of equations was effected by adopting the following sequence of operations when satisfying the compatibility and equilibrium conditions at the junction of the cylinder, cylinder head and skirt.

(1) Assume that the components of the structure (i.e. cylinder, cylinder head and skirt) can deflect and rotate with no constraining effect at the discontinuity. At the same time assume the structure free to develop the membrane stresses it would obtain under a similar external load system if its components were joined and could develop induced moments and shear forces.

(2) Calculate the horizontal displacements and tangential rotations of the components of the structure at the discontinuity, assuming no interacting constraining effects.

(3) Apply to each component of the structure a moment and shear force at its edge, and let these moments and shear forces be chosen to suppress the displacements and rotations the ends of the components would develop if free to assume unconstrained movements. These moments and shear forces will be simple functions of the applied loading and can be calculated readily when dealing with any particular example.

(4) Sum the moments and shear forces in item (3) to determine the external moment and shear force which must be applied externally to the loaded structure at the point of discontinuity to suppress any displacements and rotations of the structure as a whole. These moments and shear forces are unbalanced and must be eliminated at a later stage in the analysis.

(5) Calculate the moment and shear force which must be applied to each component of the structure to give a radial displacement Δ with no accompanying rotations. It will be found that all these moments and shear forces can be expressed in terms of one unknown quantity. That is, they can be expressed in terms of Δ or one of the unknown moments or shear forces acting on the components of the vessel due to the arbitrary radial displacement Δ.

(6) Sum the moments and shear forces in item (5) to determine the external moment and shear force which must be applied to the structure at the discontinuity to obtain a displacement with no accompanying rotation.

(7) Calculate the moment and shear force which must be applied to each component of the structure to give a tangential rotation θ with no accompanying displacement. These moments and shear forces can be expressed in terms of a further unknown as explained in item (5).

(8) Sum the moments and shear forces in item 8 to determine the external moment and shear force which must be applied to the structure to give a rotation θ with no accompanying radial displacement.

(9) Determine the two unknown parameters associated with items (6) and (8) by considering the equilibrium of the moments and shear forces acting on the structure at its point of support. These moments and shear forces are given by the procedure of items (4), (6) and (8).

As already stated, by following the above procedure the problem reduces to the solution of two simultaneous equations to obtain the parameters which determine the moments and shear forces induced in the cylinder, cylinder head and skirt.

It is worth noting that the method of solution described above can be applied to multi-connected surfaces of revolution when any number of components are joined at the discontinuity. For example, the spherical reactor vessel with an inner and outer skirt previously discussed.

It is hoped to publish the full analysis for the heat exchanger structure at a later date; however, it may be of interest to say that, for any arbitrary external load system, the moments and shear forces induced in the cylinder, cylinder head and skirt can be written in the following form:

$$\text{Moment (or shear force)}=C_1+C_2F_1(r)+C_3F_2(r)$$

where $F_1(r)$ and $F_2(r)$ are functions of the dimensions of the structure and C_1, C_2 and C_3 are constants which can be determined for any particular load system.

For example, for the cylindrical component of the structure :

$$F_1(r)=\left[\frac{h_H^2}{h_C^2}+\frac{h_S^2}{h_C^2}+\frac{h_H^{5/2}}{h_C^{5/2}}+\frac{h_S^{5/2}}{h_C^{5/2}}\right]$$

$$F_2(r)=\left[1+\frac{h_H^2}{h_C^2}+\frac{h_S^2}{h_C^2}+\frac{2h_H^{3/2}}{h_C^{3/2}}+\frac{2h_S^{3/2}}{h_C^{3/2}}\right]$$

where

h_C = thickness of cylinder
h_H = thickness of cylinder head
h_S = thickness of skirt

Comparing the two methods of analysis considered above, it may be said that although the method of solution used to determine the induced stresses in the heat exchanger structure involved the solution of a smaller number of simultaneous equations than in the case of the reactor pressure-vessel structure, on the whole the amount of work associated with each method of solution is about the same for the complete analysis of any particular problem.

General Information

As a matter of practical interest, it may be pointed out that for the G.E.C./Simon-Carves design, in view of the continued improvement in site welding techniques and as a result of the experience of Motherwell Bridge and Engineering Company on the construction of the spherical vessels at Dounreay, it was decided that 3in plate could be welded to the exacting standards necessary for reactor pressure vessels. Thus, with a maximum plate thickness of 3in and a design pressure of 165 lb per square inch for the coolant CO_2, the diameter of the sphere was taken as 70ft.

When considering the materials from which the spherical pressure vessel could be constructed, it was concluded that no steel could be found which combined the desirable features of high notch ductility with good creep strength at high temperature and easy weldability. As a result it was decided to have a double shell, the outer of which would be a spherical pressure vessel but would be maintained at a temperature below the creep region by allowing a bleed of the incoming cool gas to flow over its inner surface before passing through the reactor. The maximum temperature of this outer shell has been fixed at 250 deg. Cent. and "Coltuf 28" was chosen as the most suitable material. "Coltuf 28" is a steel that is readily weldable and has a low ductile/brittle transition temperature. The inner cylindrical shell which confines the reactor and which will attain temperatures comparable with the maximum temperatures of the fuel channels is to be constructed of boiler plate having a thickness of 1½in.

Finally, with regard to the skirts, these are both constructed of "Coltuf 28", and are designed to carry loads in the order of 6000 tons.

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Proposed Nigerian Hydro-Electric Power Scheme.—Investigations are being made into the possibility of a hydro-electric project on the River Kaduna, Nigeria, at Shiroro Gorge. Preliminary calculations indicate that a dam and power station at Shiroro Gorge could produce some 400 million units of electrical energy in a year of average rainfall.

Performance and Efficiency Tests on B.R. Class "8" Locomotive

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E., M.I.Loco.E.

No. I

The tests on this locomotive, the ultimate development of the steam express passenger locomotive in this country, have been conducted in the manner now customary with work done under the auspices of the Locomotive Testing Joint Sub-Committee of the British Transport Commission. Here the author comments upon results that are of great interest, particularly in view of the broader application of the data obtained to the economic operation of train services.

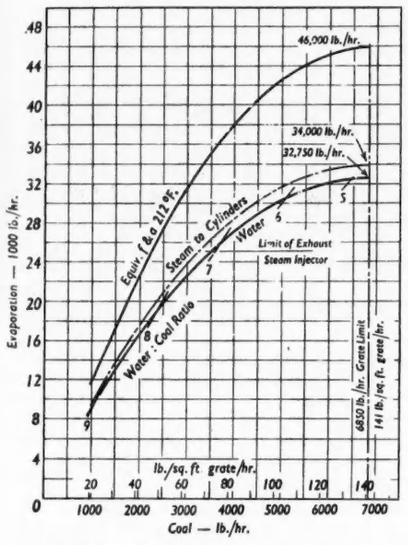
It is with somewhat mixed feelings that the present author took up the task of commenting upon the official bulletin setting forth test results on what will almost certainly be the last steam locomotive to be designed specially for express passenger service on the railways of this country. To one who had long "worshipped at the shrine of the steam locomotive"—to quote a memorable phrase of the late Loughnan Pendred—it would have been all too easy to become reflective, nostalgic and perhaps even sentimental. But successive bulletins issued by the British Transport Commission dealing with locomotive testing, have so effectively stripped away the aura of mystery and uncertainty surrounding much locomotive performance recorded in the past as to reduce all to the plainest fact. The bulletin dealing with the class "8" 4–6–2 engine is, indeed, one of the longest and most comprehensive so far issued ; in some respects, however, one wishes that the Committee would occasionally depart from a plain recital of fact, and hazard an explanation for certain aspects of the results that will probably puzzle many students of locomotive performance.

Before discussing the actual results the principal features of the locomotive design may briefly be mentioned. The policy of British Railways since nationalisation has been to design standard locomotives with no more than two cylinders, and the class "7" mixed traffic 4–6–2 ("Britannia" class) has two cylinders 20in diameter by 28in stroke, to yield a nominal tractive effort of 32,150 lb at 85 per cent boiler pressure. The class "8" express passenger locomotive was required to have a nominal tractive effort of approximately 40,000 lb. It was not possible to accommodate within the limits of the loading gauge two cylinders of the size that would be required to give this tractive effort, and so three cylinders were decided upon, with steam distribution effected by use of the British-Caprotti valve gear. The boiler is the same as that of the "Britannia," but with a larger firebox having a grate area of 48·6 square feet against 42 square feet in the two-cylinder engine. In view of the results obtained from the class "8" engine, the relative boiler proportions are tabulated below alongside those of other British "Pacific" locomotives.

The author was privileged to see some of the tests in progress on the B.R. class "8" locomotive, both on the stationary plant at Swindon and on the road, when running controlled tests with the dynamometer car, and certain impressions formed then have been fully borne out in the published results : those impressions were, first and foremost, of high coal consumption. On the Swindon test plant the locomotive was steamed up to the limit of the grate, and on examination of

Engine class	ex L.N.E.R. "A4"	ex L.M.S. "Duchess"	B.R. "Britannia"	B.R. Class "8"
Nominal tractive effort (lb), 85 per cent boiler pressure	35,455	40,000	32,150	39,080
Heating surfaces :				
Firebox, square feet	231·2	230	210	226
Tubes, square feet	1281·4	1544	1285	1285
Flues, square feet	1063·7	1033	979	979
Total evaporative	2576·3	2807	2474	2490
Superheater :				
Number of elements	43	40	40	40
Heating surface, square feet	748·9	830	718	691
Total heating surface, square feet	3325·2	3637	3192	3181
Grate area, square feet	41·25	50	42	48·6
Total free area through tubes/grate area, per cent	15·1	13·8	16·2	14·0

the graph, Fig. 1, surprise may well be expressed that the grate limit was reached at so relatively low an evaporation rate as 34,000 lb per hour, steam to cylinders. Even this maximum was only reached at the expense of the very high coal consumption of 6850 lb per hour. The graph, Fig. 1, relates to the



South Kirkby coal, 13,550 B.Th.U. per pound. Exhaust steam injector.

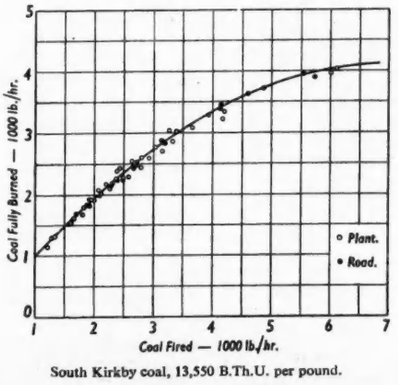
Fig. 1—Evaporation

use of Grade 1A hard coal (South Kirkby); on the 2B coal (Blidworth) common to all tests made nowadays, firing up to the grate limit, 6850 lb, yielded an evaporation of no more than 30,250 lb per hour, steam to cylinders. The highest rate of evaporation at which tests were conducted on the road was 30,000 lb per hour, requiring a coal consumption of 4850 lb per hour.

On the "Britannia" class locomotives, the tests at Rugby, commented upon in THE ENGINEER for July 24 and July 31, 1953, the evaporation rates, using South Kirkby coal, make an interesting comparison with those of the B.R. "8" locomotive, as follows:

Coal rate, lb per hour	Evaporation (steam to cylinders)	
	"Britannia"	B.R. "8"
1500	13,750	13,750
2000	17,500	17,500
2500	21,250	20,900
3000	24,500	23,700
3500	27,500	26,200
4000	30,000	28,500

According to this published data, the "Britannia" gives the better results. Apart from the size of the grate, the other important difference between the "steam circuit" of the two locomotives is that the B.R. "8" has a double blast-pipe and chimney. While the maximum evaporation of the "Britannia" is settled by the limit of its front end, at 31,600 lb per hour, and the grate limit is not approached by a considerable margin, the double blast-pipe of the B.R. "8" enabled the boiler to be steamed up to the grate limit, though there is evidence that at the higher rates of firing so much fuel is thrown away unburnt as to seriously affect the economy of the locomotive. In Fig. 2 is shown a graph of coal fired to coal fully burned, and it will be seen that the coal fully burned reached a maximum of about 4100 lb per hour, even though the firing rate was taken up to nearly 7000 lb per hour.



South Kirkby coal, 13,550 B.Th.U. per pound.

Fig. 2—Combustion relations

A further diagram, Fig. 3, shows one aspect of the heat balance of the boiler and shows how the loss in unburnt coal rises after the firing rate has passed the 3000 lb per hour stage. The total area of the double blast-pipe arrangement on this locomotive is 25·12 square inches, as compared with 22·69 square inches on the single blast-pipe of a "Britannia." The maximum steam rate of the B.R. "8" does not quite attain the figure one might expect from a comparison of these areas, still less does it reach a rate proportional to the relative grate areas of the B.R. "7" and B.R. "8" fireboxes.

The cylinder performance of the B.R. "8" is good and is reflected in the diagram of indicated horsepower characteristics shown in Fig. 4. With the "Britannia" class the curves of indicated horsepower for constant steam rates, reach a maximum at about 65 m.p.h. to 70 m.p.h., after which the tendency is falling—even though slightly. With the B.R. "8" the corresponding curves are still rising at 90 m.p.h. and, as usual with the British-Caprotti valve gear, the nominal cut-offs are very short. Both the B.R. "7" and B.R. "8" classes have the same driving wheel

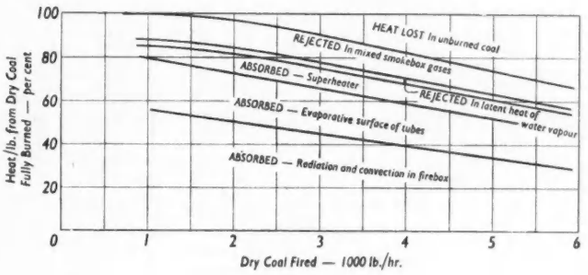

Heat/lb. from Dry Coal Fully Burned — per cent
Dry Coal Fired — 1000 lb./hr.
HEAT LOST In unburned coal
REJECTED In mixed smokebox gases
ABSORBED — Superheater
REJECTED In latent heat of water vapour
ABSORBED — Evaporative surface of tubes
ABSORBED — Radiation and convection in firebox

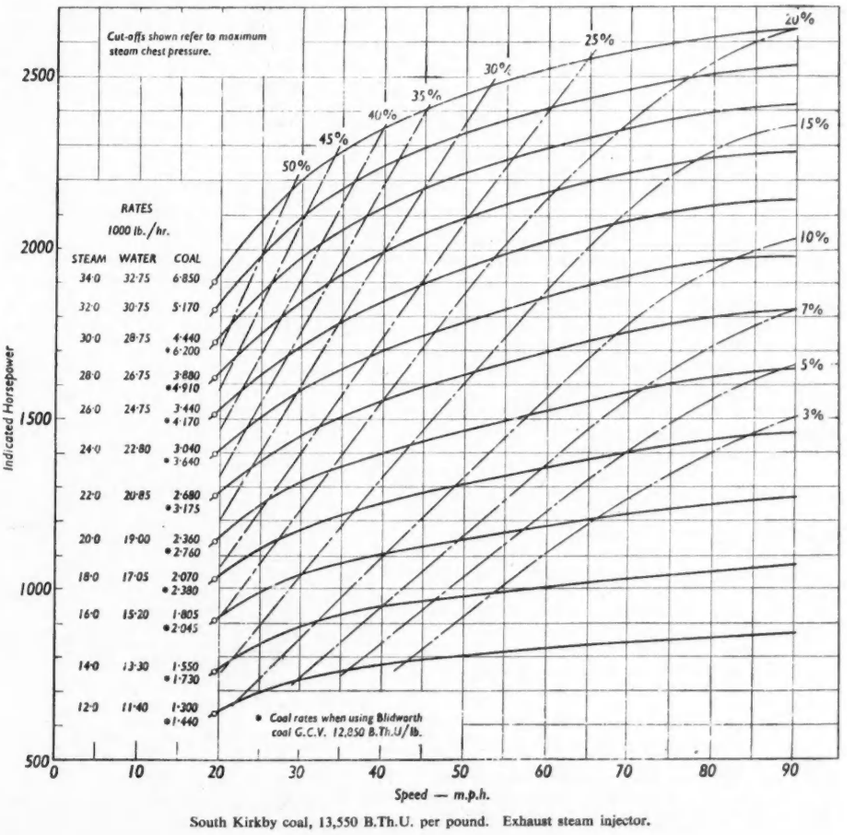
Fig. 3—Boiler heat balance

diameter and it is interesting to compare the relative power output for the same steam rates, using Grade 1A South Kirkby coal.

Speed, m.p.h.	Steam rate, lb per hour	Indicated horsepower	
		B.R. "7"	B.R. "8"
60	18,000	1345	1360
	22,000	1650	1700
	26,000	1910	2020
	30,000	2125	2300
75	18,000	1345	1420
	22,000	1650	1780
	26,000	1900	2110
	30,000	2125	2380

At 26,000 lb per hour the coal rate of the B.R. "7" is approximately 4½ per cent less than that of the B.R. "8" and at 30,000 lb it is nearly 10 per cent less.

The indicated horsepowers recorded with



South Kirkby coal, 13,550 B.Th.U. per pound. Exhaust steam injector.

Fig. 4—Indicated horsepower characteristics

the B.R. "8" locomotive are the highest, per unit of steam rate, that have so far been published by the British Transport Commission in connection with any of the class "7" and class "8" passenger and mixed traffic locomotives tested. But the rise in coal consumption at high power output becomes still more marked when lower grade fuel is being fired.

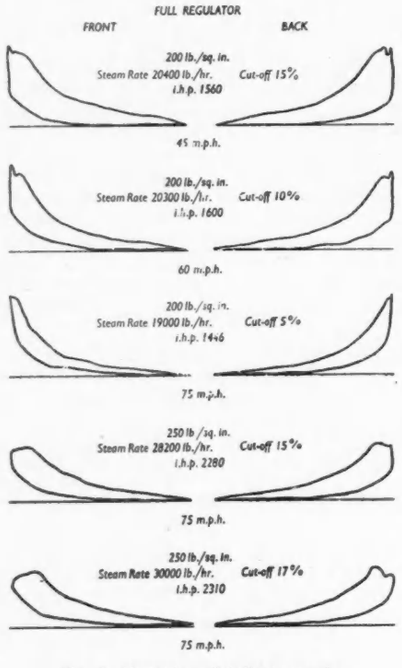


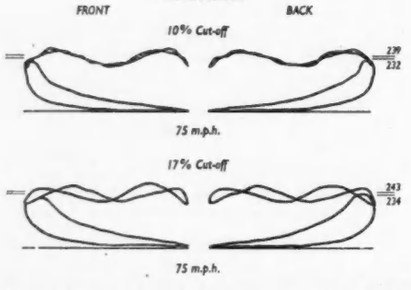
Fig. 5—Examples of indicator cards

The comparison with the "Britannia" (B.R. "7" class) is still less favourable, as shown in the accompanying table.

Locomotive	Steam rate, lb per hour	Coal rate, lb per hour	
		South Kirkby*	Blidworth†
B.R. "7" ...	24,000 30,000	2910 3999	3530 4750
B.R. "8" ...	24,000 30,000	3040 4440	3640 6200

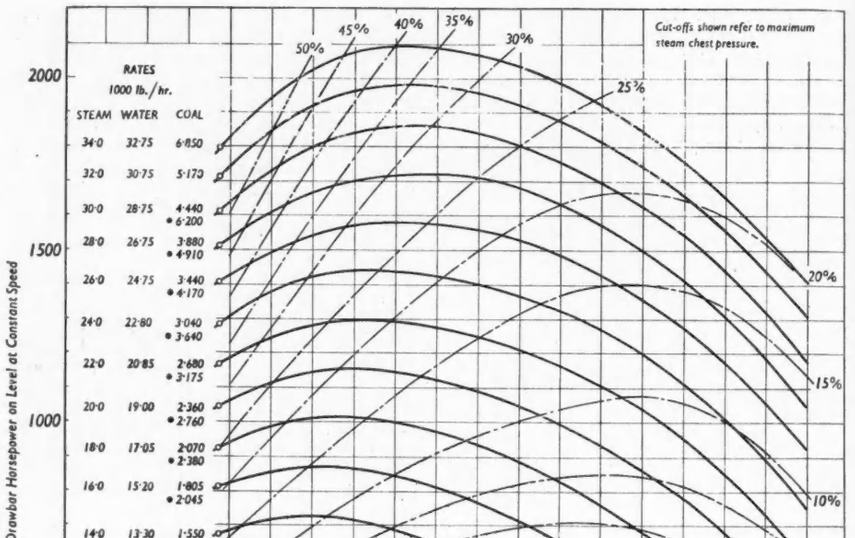
* Grade 1A : Average 13,650 B.Th.U. per lb.
† Grade 2B : Average 12,700 B.Th.U. per lb.

In Fig. 5 are reproduced some typical indicator diagrams from the published bulletins. The first three diagrams have been chosen to show conditions in average express traffic demands, at steam rates around 20,000 lb per hour. Two further diagrams, *D* and *E*, drawn to a reduced vertical scale, show performance at a much higher output of power. That relating to a steam rate of 28,200 lb per hour, with cut-off at 15 per cent, shows excellent characteristics, with an



Figures thus $\frac{243}{232}$ denote boiler pressure—pounds per square inch gauge.
Figures thus $\frac{243}{232}$ denote steam chest pressure—pounds per square inch gauge.

Fig. 6—Steam chest pressure showing degree of surge



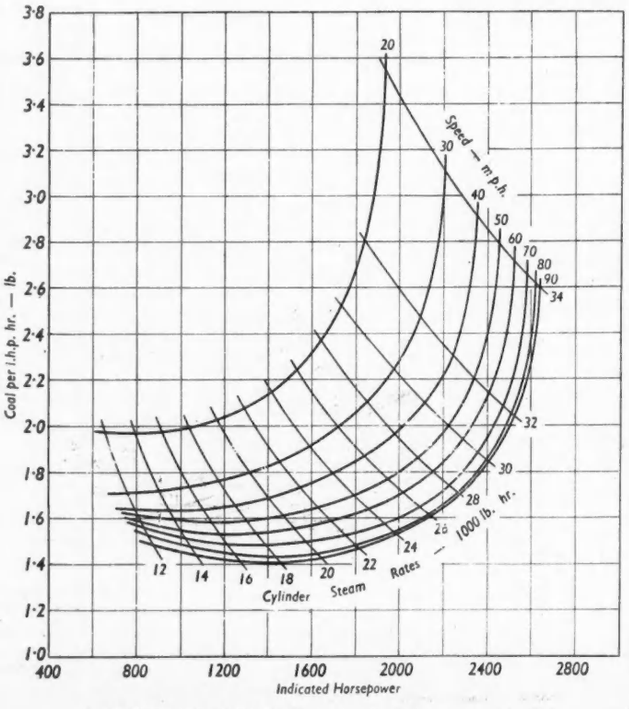
South Kirkby coal, 13,550 B.Th.U. per pound. Exhaust steam injector

Fig. 7—Drawbar horsepower characteristics

admission line almost level. The bulletin claims that specific steam consumptions with the design of British-Caprotti gear provided on this locomotive are generally lower than obtainable with the normal piston-valve gear, and that maximum economy is sustained over a wider range of working.

During testing at the highest speeds severe vibration occurred at the front end; indicators showed that this was due to heavy pulsation in the steam chest pressure at speeds above 70 m.p.h. to 75 m.p.h. Up to this range of speed the steam chest pressure remained very steady, but above it, as shown in the typical indicator diagrams in Fig. 6, severe pulsation develops. Though maximum pressure rises well above boiler pressure the minimum occurs during admission, i.e. there is a "depressed" admission. There is no substantial evidence, however, that cylinder thermal efficiency is affected, probably because no heat loss is involved. The periodicity of the pulsation is governed by crank phrasing and speed, but length and volume of steam passages are contributory factors in the production of the pulsation. The most troublesome effect is the vibration set up in all parts that are in association with the main steam pipes. Whilst indicators were directly attached to the cylinder casting as could be done at the testing plant, the effect on indicating was not evident in any way. The effect of the "depressed admission" is plainly shown in the 30,000 lb/hr diagram in Fig. 5.

The B.R. "8" locomotive is very free-



South Kirkby coal, 13,550 B.Th.U. per pound. Exhaust steam injector

Fig. 8—Steam and coal per indicated horsepower-hour

running and this yields some excellent drawbar horsepower characteristics. The author was first aware of this when he was privileged to ride in the dynamometer car on a run with a twenty-coach train of 610 tons tare, at a steam rate of 30,000 lb per hour ; on a gradient no steeper than 1 in 1500 east of Didcot speed was maintained at 80 m.p.h. to 82 m.p.h. The drawbar characteristics are shown in Fig. 7, and it will be seen that despite the tendency to high coal consumption the other factors that contribute to the overall performance are sufficiently good to provide for a drawbar horsepower of 1000, at 80 m.p.h., on a coal rate only slightly exceeding 3000 lb per hour, with grade 1A coal. This is the maximum rate that is expected to be sustained continuously in any service ; but, on the other hand, a sustained drawbar horsepower of 1000, at 80 m.p.h., is more than is generally required at such speeds in ordinary conditions of running.

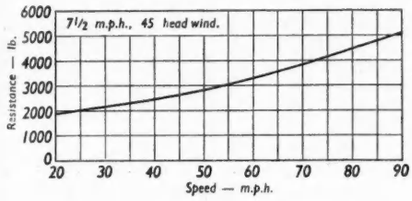


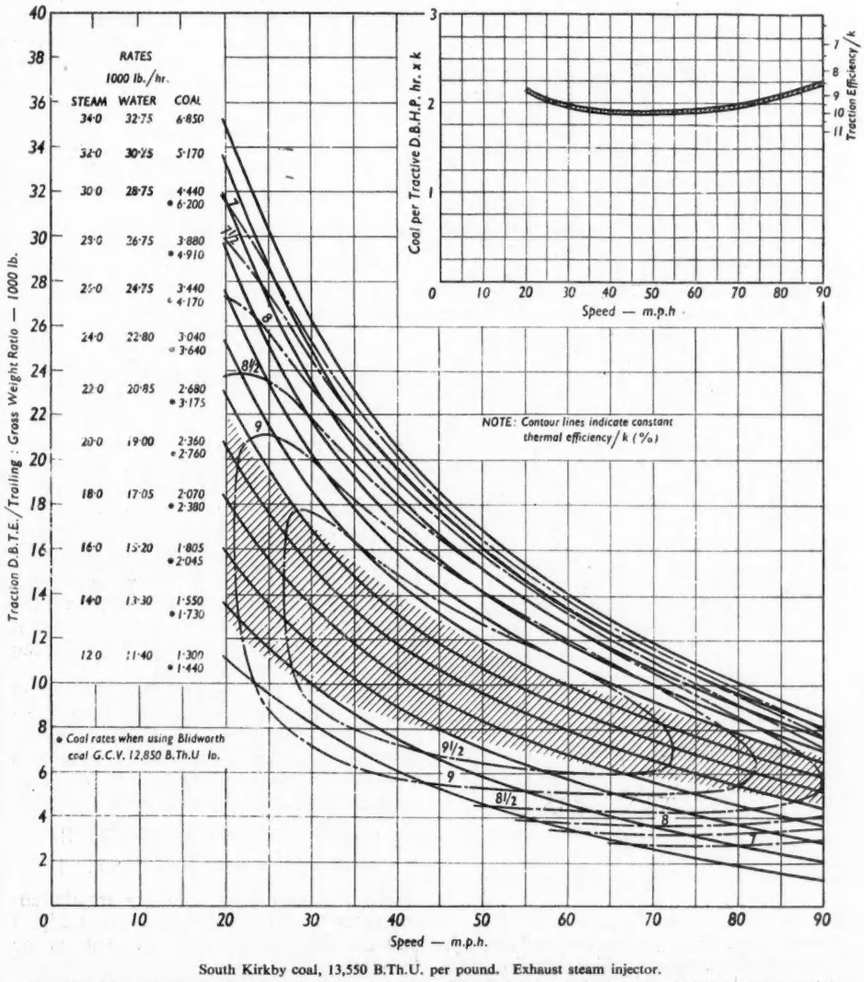
Fig. 9—Total resistance of locomotive

In connection with the free-running qualities of the locomotive, the graph showing the resistance at various speeds, Fig. 9, will be of interest. In dealing with the tests on the "Britannia" locomotives, the present author, in THE ENGINEER for July 31, 1953, had occasion to comment on the very peculiar resistance characteristics that could be deduced from other data published in the official bulletin, rising only slightly from 19 lb per ton at 40 m.p.h. to 21·6 lb per ton at 70 m.p.h. This characteristic was so unusual as to be "suspect," and to throw doubts upon the drawbar characteristics of the engines concerned. At that time in British Railways testing practice, however, the procedure for cross-checking and reconciliation of results was not so highly developed as it is to-day, and discrepancies were more likely to be found. This particular point has been recalled, however, in view of the "family association" between the B.R. "7" and B.R. "8" locomotives, and the comparisons that will inevitably be made between test results from one and from the other. From the graph, Fig. 9, the specific resistance of the B.R. "8" rises from 16 lb per ton at 40 m.p.h. to 24·7 lb at 70 m.p.h. and 30·7 lb per ton at 85 m.p.h.

In previous bulletins composite diagrams have been included showing the coal consumption per indicated horsepower hour and per drawbar horsepower hour; but in the case of the B.R. "8" locomotive only that relating to the indicated horsepower is published. This latter diagram is reproduced in Fig. 8 for Grade 1A South Kirkby coal. Instead of a set of basic relations for coal per drawbar horsepower hour, as in most previous bulletins, the characteristic variations of the drawbar tractive effort are now related to the trailing/gross weight ratio of the trains to be hauled, and the diagram, Fig. 10, shows, in addition to these relations, the range of working for which traction efficiency/trailing gross weight ratio is within 2 per cent of the maximum recorded with the locomotive. In passing, it is interesting to see that in this bulletin distinction is now made between the tare and loaded weight of passenger trains. Hitherto it has been an almost invariable practice to base, not only loading regulations but also test results, upon the tare weight ; now, an allowance of 10 per cent over tare weight is made in respect of what the bulletin terms "useful" load. Taken all round, an allowance of 10 per cent for a corridor train including dining or buffet accommodation would appear to be considerably above average. Few trains in Britain would show an increase much above 5 per cent at normal times.

In a further article the controlled road tests run with the B.R. "8" locomotive will be discussed, together with their application to the planning of train schedules on the London Midland main line between Euston and Carlisle.

(To be concluded)



South Kirkby coal, 13,550 B.Th.U. per pound. Exhaust steam injector.

The hatched band covers all rates of working for which traction efficiency/trailing: gross weight ratio is within 2 per cent of the maximum as shown in inset diagram.

Fig. 10—Characteristics of traction d.b.t.e./trailing: gross weight ratio

Aeronautical Conference

THE sixth Anglo-American Aeronautical Conference will be held at the Hotel Metropole, Folkestone, from September 9 to 12. Attendance is limited to members of the Royal Aeronautical Society and the Institute of the Aeronautical Sciences. The lecture programme is as follows:—

MONDAY, SEPTEMBER 9

9.15 a.m.: "NACA Research on VTOL and STOL Aeroplanes," Marion O. McKinney, Jr.

11 a.m.: "Nuclear Mobile Propulsion with Particular Reference to Aircraft," Dr. J. V. Dunworth.

2 p.m.: "Control of Supersonic Propulsion Systems," John C. Sanders.

4 p.m.: "The Electrical Control of Power Plants," G. M. Sturrock.

TUESDAY, SEPTEMBER 10

9.15 a.m.: "Alleviation of Kinetic Heating Stresses," J. Taylor.

11 a.m.: "Nine Years of Titanium Usage," Leo A. Schapiro and Emerson LaBombard.

2 p.m.: "The Use of Non-Metallic Materials at High Temperatures," Dr. W. J. Strang.

4 p.m.: "Blast Loading of Aircraft Structures," Professor R. L. Bisplinghoff and Dr. Emmett A. Witmer.

WEDNESDAY, SEPTEMBER 11

9.15 a.m.: "Safety in Relation to Structural Damage," Dr. A. E. Russell.

11 a.m.: "An Appraisal of Aeroelasticity in Design, with Special Reference to Aeroelastic Stability," Martin Goland.

2 p.m.: "The Presentation of Information by Aircraft Instruments," A. Stratton.

4 p.m.: "Increased Usable Lift through Boundary Layer Control," C. W. Harper.

THURSDAY, SEPTEMBER 12

9.15 a.m.: "The Role of Experimental Hyperballistics in the Development of Future Aeroplanes and Missiles," Dr. Herman H. Kurzweg.

11 a.m.: "Design for Repairability of Civil Turbine Engines," A. H. Harvey-Bailey.

2 p.m.: "Aerodynamic Effects of Boundary Layer Unsteadiness," F. K. Moore.

4 p.m.: "The Human Pilot as an Aircraft Operator," Squadron Leader T. C. D. Whiteside.

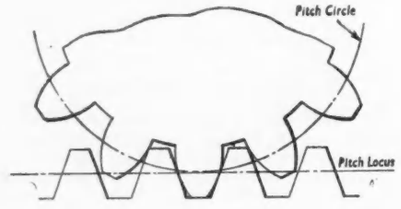
Effects of Hob Form on Tooth Profile

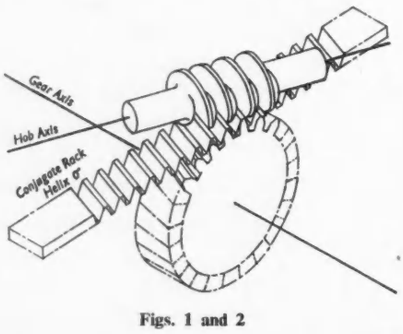
By G. B. THOMPSON, B.Sc.*

There are three kinds of hobs in general use for the manufacture of straight spur and helical gears : those ground such that their teeth are straight sided in a plane normal to the pitch helix, those ground such that their teeth are straight sided in a radial plane, and those which are involute helicoids. In B.T.H. practice the first two are used, and as the British Standards Institution now recommends the involute helicoid as giving a true involute profile, this investigation into the effects of these three types of hobs on the resultant gear tooth profile has been carried out. The method of analysis and some examples of the theoretical gear tooth profile errors produced by specific hobs are described.

The Hobbing Process

IN the hobbing process it can be taken that gears are generated by some form of imaginary rack (see Fig. 1), where the velocity of the rack, measured in the transverse plane of the gear (the plane normal to the gear axis) is equal to the velocity of the rotating gear blank at its pitch circle. The shape of the gear tooth is dependent upon the shape of the rack, which can thus be regarded as conjugate to the gear tooth profile. It is evident from Fig. 2 that the





Figs. 1 and 2

rack must in turn be conjugate to the hob. In other words, the gear form is seen to be caused by a hob rotating about its axis, with an infinitely thin imaginary rack sandwiched between the gear and the hob. Looking on the hob side of the imaginary rack, that section of the rack surface which lies in a plane normal to the hob axis will be termed the transverse basic rack of the hob, and similarly there will be a surface section which is the transverse basic rack of the gear.

Considering a helical gear as the general case, the transverse tooth profiles of the gear and its hob are therefore conjugate to their respective transverse basic racks, these being different sections of an infinitely thin imaginary rack, and normally regarded from opposite sides.

The Transverse Gear Tooth Profile Generated by a Straight-Sided Basic Rack

In Fig. 1, if we consider one flank of the basic rack moving tangentially to the pitch circle of the blank, and in the transverse plane of the gear, we can, by means of the theory of envelopes, obtain the equation to the gear tooth which would be generated by the rotation of the blank, and the movement of the basic rack flank. In Fig. 3 the rack is

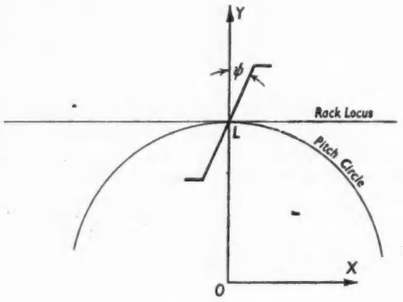


Fig. 3

shown with its pitch locus, and the pitch circle of the blank. The rack flank is shown so that it passes through the point of intersection of its locus, and the pitch circle, that part of the rack flank which coincides with the point of intersection being termed L. The rectilinear co-ordinate axes OX, OY, fixed in direction with respect to the gear blank, are such that their origin O is the centre of the gear blank pitch circle. The OY axis passes through L, when L touches the pitch circle. The rack pressure angle ψ is the included angle between the OY axis, and the rack flank, measured when OY passes through L.

In order to simulate the hobbing process the rack velocity measured in the transverse plane must be equal to the velocity of the blank along the pitch circle. It is therefore evident that the locus of L with respect to the OX-OY axes is an involute to the pitch circle of the gear blank. This is shown in Fig. 4,

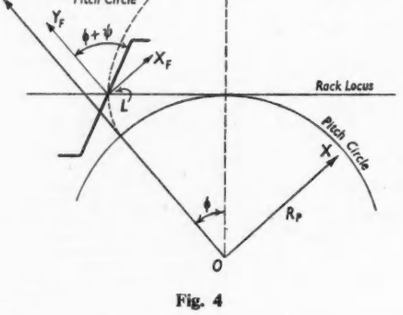


Fig. 4

where the gear blank has been rotated through an angle ϕ in an anticlockwise direction, and L has moved a distance $R_p\,\phi$ to the left, R_p being the pitch circle radius of the blank. If the co-ordinates of L with respect to the OX OY axes are x_L, y_L, then from the equation of an involute to a circle

$$x_L = R_p(\sin\phi - \phi\cos\phi) \quad . \quad . \quad . \quad . \quad (1)$$

and

$$y_L = R_p(\cos\phi + \phi\sin\phi) \quad . \quad . \quad . \quad . \quad (2)$$

If the co-ordinate axes LX_F and LY_F are then applied to the rack flank (see Fig. 4) such that the origin is at L, and they are always parallel to the OX, OY axes, then the equation to the rack flank with respect to LX_F, LY_F is

$$y_F = x_F\cot(\phi+\psi) \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Therefore, for any rotation ϕ the equation to the rack flank with reference to the OX, OY axes is such that

$$x_F = x - x_L$$

and

$$y_F = y - y_L$$

From equations (1), (2) and (3) it therefore follows that

$$y - R_p(\cos\phi+\phi\sin\phi) = \cot(\phi+\psi)\,[x - R_p(\sin\phi-\phi\cos\phi)]$$

which reduces to

$$x\sin\phi + y\cos\phi - R_p = \cot\psi\,(x\cos\phi - y\sin\phi + R_p\phi) \quad . \quad (4)$$

Equation (4) is the general equation to the family of straight lines produced by the rack flank, with respect to the OX, OY axes, for any rotation ϕ of the gear blank.

On differentiating with respect to ϕ, equation (4) becomes

$$x\cos\phi - y\sin\phi = \cot\psi\,(R_p - x\sin\phi - y\cos\phi) \quad . \quad (5)$$

By the theory of envelopes the solution to equations (4) and (5) will give the equation to the envelope generated in the transverse section of the gear blank.

From equations (4) and (5)

$$x\cos\phi - y\sin\phi = -\cot^2\psi\,(x\cos\phi - y\sin\phi + R_p\phi)$$

which reduces to

$$x\cos\phi - y\sin\phi = -R_p\phi\cos^2\psi$$

but we know from involute geometry that

$$R_p\cos\psi = R$$

where R is the base circle radius of the gear being generated. Hence it follows

$$x\cos\phi - y\sin\phi = -R\phi\cos\psi \quad . \quad . \quad . \quad (6)$$

Substituting equation (6) into (5),

$$x\sin\phi + y\cos\phi = R\phi\sin\psi + R\sec\psi \quad . \quad (7)$$

and, solving equations (6) and (7),

$$x = R[\sin\phi\sec\psi - \phi\cos(\phi+\psi)] \quad . \quad . \quad (8)$$

$$y = R[\cos\phi\sec\psi + \phi\sin(\phi+\psi)] \quad . \quad . \quad (9)$$

Equations (8) and (9) give the co-ordinates of the transverse gear tooth profile generated by a straight-sided transverse basic rack, where the OY axis passes through the pitch point of the profile. It will be noticed that when $\phi = 0$, x and y become the co-ordinates of the pitch point of the gear tooth.

It will now be shown that equations (8) and (9) define an involute to a base circle radius R. From Fig. 5 it is evident that the co-ordinates of an involute to the same axes and base circle as those of the envelope (equations (8) and (9)) are :

$$y = R[\cos(\psi+\theta) + (\delta+\psi+\theta)\sin(\psi+\theta)]$$

$$x = R[\sin(\psi+\theta) - (\delta+\psi+\theta)\cos(\psi+\theta)]$$

where θ is zero when x and y are the co-ordinates of the pitch point. From Fig. 5 and the definition of an involute it can be seen that

$$R\tan\psi = R(\delta+\psi)$$

or

$$\delta = \tan\psi - \psi \quad . \quad . \quad . \quad . \quad (10)$$

* British Thomson-Houston Company, Ltd.

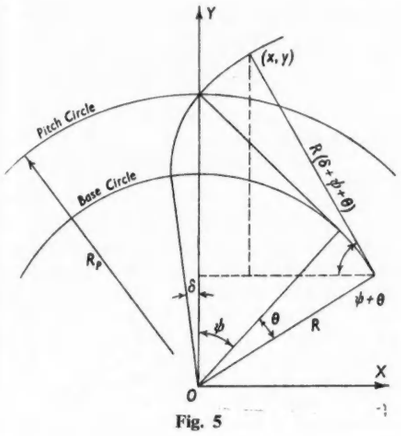


Fig. 5

It therefore follows that

$$y=R[\cos(\psi+\theta)+(\tan\psi+\theta)\sin(\psi+\theta)]$$

and

$$x=R[\sin(\psi+\theta)-(\tan\psi+\theta)\cos(\psi+\theta)]$$

which reduce to

$$y=R[\cos\theta\sec\psi+\theta\sin(\psi+\theta)]$$

$$x=R[\sin\theta\sec\psi-\theta\cos(\psi+\theta)].$$

It is evident that when θ is equal to ϕ, the above two equations become equations (8) and (9), so that the transverse tooth profile generated by a straight-sided transverse basic rack, must be a true involute to a circle. It is therefore evident that before a hob can generate an involute tooth form, it must be conjugate to a straight-sided rack. Such a hob will have an involute tooth profile in its transverse plane. The involute helicoid hob satisfies this condition, and is therefore the only hob which can generate a true involute gear tooth profile.

The Relationship Between Transverse Basic Rack Errors and Gear Tooth Profile Errors

We know two facts relating to the hobbing process :

(1) The basic rack velocity measured in the transverse plane of the gear blank is equal to the velocity of the blank at its pitch circle.

(2) A straight-sided basic rack of either spur or helical form will generate an involute tooth form in the transverse section of the gear.

Two positions of the gear tooth and its rack are shown in Fig. 6. In position 1, the point of contact is L_1, that is, at the pitch point of the gear tooth profile. In position 2 the gear has been rotated through an angle θ, in an anti-clockwise direction, and the point L has moved a distance $R_p\theta$ to the left to L_2.

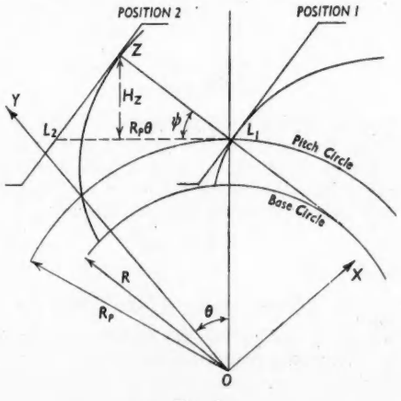


Fig. 6

The point of contact of the tooth profile and the rack now becomes Z. The co-ordinates of Z with reference to the OX, OY axes are therefore

$$y=R[\cos\theta\sec\psi+\theta\sin(\psi+\theta)]$$

and

$$x=R[\sin\theta\sec\psi-\theta\cos(\psi+\theta)]$$

where R is the base circle radius of the gear. The point of contact can also be specified with respect to the rack flank, by measuring the vertical height of Z, H_z, above the rack pitch locus. From Fig. 6 it is evident that

$$H_z=R_p\theta\sin\psi\cos\psi \quad . \quad . \quad . \quad . \quad (11)$$

where ψ is the transverse pressure angle of the rack and gear. We can therefore state that the point of contact between the transverse gear tooth profile and the rack at a height H_z will have a generating angle θ which is governed by equation (11).

If we now consider a rack flank which is not straight-sided in the transverse plane, but has an error ε_z in that plane (see Fig. 7)

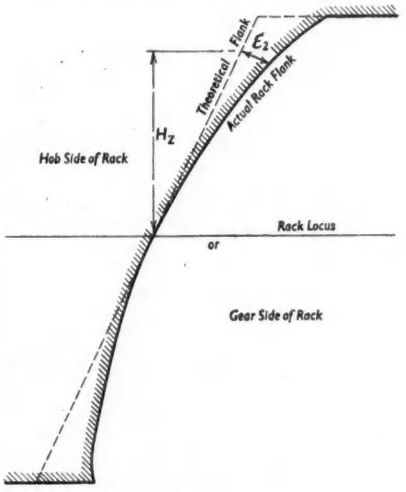


Fig. 7

at a rack height H_z where the error is measured normal to the theoretical rack flank (straight sided), ε_z being positive if it generates a protuberance on the gear tooth profile, and negative if it generates a hollow, then the gear will have a transverse profile error ε_z measured normal to the theoretical involute, which has a generating angle θ as given by equation (11). (However, because of the sliding action which is also present between the rack flank and the gear tooth, this statement is only valid if the negative radius of curvature of the rack flank is greater than the radius of curvature of the involute at the point of contact. This condition is generally satisfied when considering the small transverse basic rack errors arising from differences in hob form.)

Types of Hob

There are three types of hobs in general use for the manufacture of involute helicoid gears. They are :

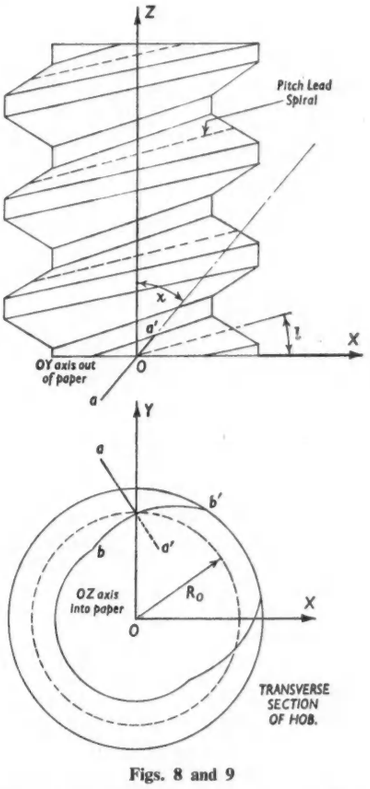
(1) Hobs ground so that their teeth are straight sided in a radial plane. These are termed axially straight hobs.

(2) Those ground such that their teeth are straight sided in a plane normal to the pitch helix.

(3) Those which are involute helicoids.

An involute helicoid is such that the transverse tooth profile is an involute, so that the straight generating line is tangential to the base cylinder helix.

Hob Transverse Tooth Profiles.—Hobs can be regarded as worm screws which have been gashed in a direction approximately normal to the pitch helix, in order to provide cutting edges, which remain, however, as part of the worm screw surface. All three types of hobs can be generated from a straight line following the pitch helix. In the cases of axially and normally straight hobs, the relative position of the straight generator is clear. However, in the case of involute helicoids the generator still follows the pitch helix, but it is also tangential to the base cylinder helix. Two elevations of a right-hand, single-start hob are shown in Figs. 8 and 9, with the three rectilinear co-ordinate axes OX, OY and OZ, applied to them. The OZ axis lies along the axis of rotation of the hob (see Fig. 8). The OX, OY axes lie in the transverse section of the hob (see Fig. 9), such that the OY axis passes through the pitch point of the hob transverse tooth profile bb'.



Figs. 8 and 9

If the straight generating line aa' (see Figs. 8 and 9) and the pitch lead spiral intersect at $x=0$, $y=R_0$, and $z=0$, where R_0 is the pitch circle radius of the hob, then having the equation of aa' with respect to the three axes, we can find the equation to the surface generated by the line, as it follows the hob pitch lead spiral. This will give the surface equation of one flank of the hob tooth. When considering multi-start hobs the equation will be that of one flank of one of the hob teeth.

The generating line aa' is shown with respect to its three co-ordinate axes in Fig. 10. If a fourth co-ordinate axis OP is introduced, so that the generating line lies in the OY, OP plane, and its equation with respect to these axes is

$$y=-p\tan\eta+R_0 \quad . \quad . \quad . \quad . \quad (12)$$

where the included angle between the OY-OP and OY-OZ planes is χ, then for any point on aa'

$$x=p\sin\chi \quad . \quad . \quad . \quad . \quad . \quad (13)$$

and

$$z=p\cos\chi \quad . \quad . \quad . \quad . \quad . \quad (14)$$

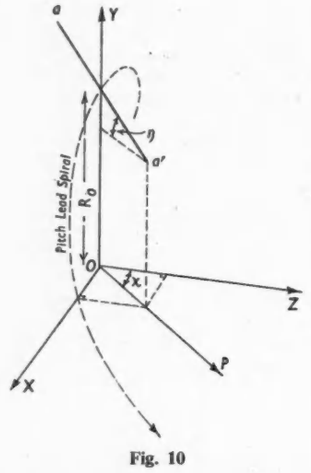


Fig. 10

If the generating line aa' then follows the pitch lead spiral, so that the rotation measured in the OX-OY plane is ω, then for any point on aa' it follows that

$$y=(R_0-p\tan\eta)\cos\omega-p\sin\chi\sin\omega \quad . \quad (15)$$

$$x=p\sin\chi\cos\omega+(R_0-p\tan\eta)\sin\omega \quad . \quad (16)$$

and

$$z=p\cos\chi+R_0\omega\tan l \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

where l is the hob pitch lead angle.

Equations (15), (16) and (17) together give the surface equation to the hob, with reference to its co-ordinate axes OX, OY and OZ. In order to obtain the equation to the transverse section of the hob z must be equal to zero. Therefore from equation (17)

$$p=-\frac{R_0\omega\tan l}{\cos\chi}.$$

Substituting into equations (15) and (16) we obtain the equations to the co-ordinates of the hob transverse tooth profile, x_T and y_T, where

$$x_T=R_0\left[\left(1+\frac{\omega\tan l\tan\eta}{\cos\chi}\right)\sin\omega-\omega\tan l\tan\chi\cos\omega\right] \quad . \quad (18)$$

$$y_T=R_0\left[\left(1+\frac{\omega\tan l\tan\eta}{\cos\chi}\right)\cos\omega+\omega\tan l\tan\chi\sin\omega\right] \quad . \quad (19)$$

Knowing the values of the four constants R_0, l, χ, and η, for any particular hob, we can calculate the co-ordinates of the transverse tooth profile by varying ω in equations (18) and (19).

Hob Design.—To generate a helical gear of transverse pressure angle ψ and helix angle σ the normal pressure angles of both the hob and gear must be ψ_N, as given by the well-known equation

$$\tan\psi_N=\tan\psi\cos\sigma \quad . \quad . \quad . \quad (20)$$

A three-dimensional view of an infinitely small area on the pitch line of one flank of the conjugate rack of the hob and the gear is shown in Fig. 11. Over this small area the rack flank can be considered as a plane. The projection of the hob axis is shown together with the sections of the conjugate transverse basic racks of the hob and gear. To be correct, the transverse basic racks of the hob and gear should be considered as on opposite sides of the conjugate rack flank, so that if the conjugate rack of the hob was concave then that of the gear would be convex, or vice versa. However, as we are considering the geometry of an infinitely small plane area we can consider both conjugate racks as being on the same side of the surface. The straight generating line aa' and the normal section of the rack are shown. AB is the pitch line of the flank.

It can be seen from Fig. 11 that

$$P'N\cot\psi_N=P'E\cot\psi_H=P'F\cot\psi=P'a'\tan\eta \quad . \quad . \quad . \quad . \quad . \quad (21)$$

where ψ_H is the transverse pressure angle of the hob. It can also be seen that

$$P'F\cos\sigma=P'N=P'a'\cos(\chi+l) \quad . \quad . \quad (22)$$

It follows from equations (21) and (22) that

$$\tan\eta=\frac{\cot\psi\cos(\chi+l)}{\cos\sigma}$$

and therefore

$$\tan\eta=\frac{\cot\psi\cos\chi(\cos l-\tan\chi\sin l)}{\cos\sigma} \quad . \quad (23)$$

From Fig. 11

$$P'E\sin l=P'N=P'F\cos\sigma \quad . \quad . \quad (24)$$

but

$$\frac{P'F}{P'E}=\frac{\text{circular pitch of gear}}{\text{circular pitch of hob}}=\frac{\pi/D}{\text{C.P. hob}}$$

so that

$$\frac{\pi/D}{\text{C.P. hob}}=\frac{\sin l}{\cos\sigma}$$

where D is the diametrical pitch of the gear. However, the ratio of the axial pitch to the circular pitch of the hob is equal to the tangent of the pitch lead angle or

$$\frac{\sin l}{\cos\sigma}=\frac{\pi/D\tan l}{\text{axial pitch hob}}$$

but

$$\text{oval pitch hob}=\frac{2\pi R_0\tan l}{S}$$

where S is the number of starts or threads, whence

$$R_0=\frac{S\cos\sigma}{2D\sin l} \quad . \quad . \quad . \quad . \quad (25)$$

From equations (21) and (24)

$$\cot\psi_H=\frac{\sin l\cot\psi}{\cos\sigma} \quad . \quad . \quad . \quad (26)$$

On substituting equations (23) and (26) into (18) and (19) we obtain

$$x_T=R_0\sin\omega[(1+\omega\cot\psi_H)-\tan\chi\{\omega\tan l(\cot\omega+\cot\psi_H)\}] \quad . \quad . \quad . \quad . \quad . \quad (27)$$

$$y_T=R_0\cos\omega[(1+\omega\cot\psi_H)+\tan\chi\{\omega\tan l(\tan\omega-\cot\psi_H)\}] \quad . \quad . \quad . \quad . \quad . \quad (28)$$

From equations (25), (26), (27) and (28) it is possible to calculate the co-ordinates of the transverse profile of a hob ground straight sided in any section. It is evident from Fig. 8 that χ is equal to zero for a hob ground straight sided in the axial section and that $\chi=-l$ for a hob ground straight sided in a section normal to the pitch helix.

Thus the transverse tooth profile co-ordinates of a hob ground straight sided in the axial section are

$$x_T=R_0\sin\omega(1+\omega\cot\psi_H)$$

$$y_T=R_0\cos\omega(1+\omega\cot\psi_H).$$

The profile co-ordinates of a hob ground straight sided in the normal section are

$$x_T=R_0\sin\omega[(1+\omega\cot\psi_H)+\omega\tan^2 l(\cot\omega+\cot\psi_H)]$$

$$y_T=R_0\cos\omega[(1+\omega\cot\psi_H)-\omega\tan^2 l(\tan\omega-\cot\psi_H)]$$

where the values of R_0 and ψ_H can be derived from equations (25) and (26) respectively.

Relationship Between Hob Transverse Profile Errors and Hob Transverse Basic Rack Errors.

As has been seen, the hob transverse tooth profile required to generate a perfect involute helicoid gear is an involute to a base circle of radius R_H, where

$$R_H=R_0\cos\psi_H.$$

In Fig. 12 the transverse tooth profile of an involute helicoid hob is shown dashed,

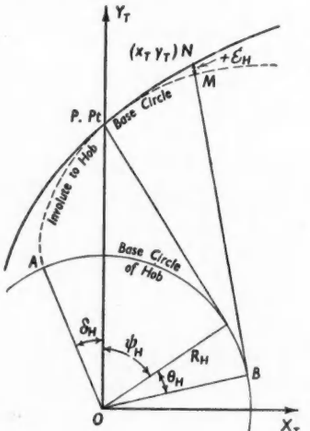


Fig. 12

together with the transverse tooth profile of a straight-sided hob. If a point N on the transverse tooth profile of such a hob protrudes beyond the theoretical by an amount $+\varepsilon_H$ or MN measured along BM, we can write

$$\varepsilon_H=BN-BM$$

but

$$BN=(x_T^2+y_T^2-R_0^2\cos^2\psi_H)^{\frac{1}{2}}$$

where x_T and y_T are the co-ordinates of N, and from the definition of an involute to a circle,

$$BM=R_0\cos\psi_H(\delta_H+\psi_H+\theta_H).$$

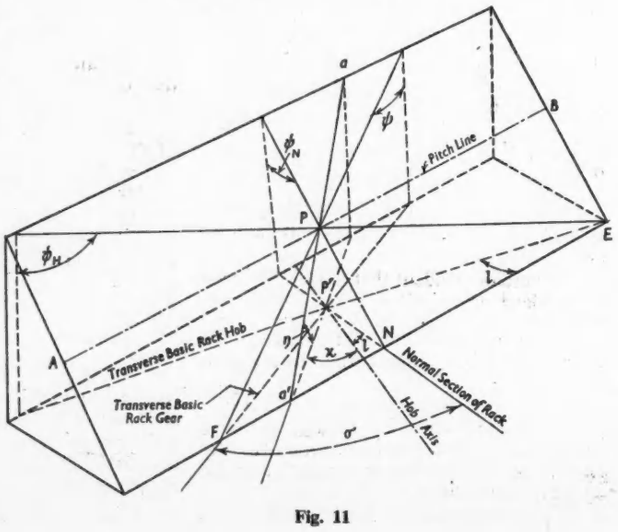


Fig. 11

The values δ_H, ψ_H, and θ_H are shown in Fig. 12, θ_H being the generating angle of the point M on the theoretical involute.

From equation (10) :

$$\delta_H = \tan\psi_H - \psi_H$$

thus

$$BM = R_0 \cos\psi_H (\tan\psi_H + \theta_H)$$

and the positive transverse profile error of ε_H of a hob at a generating angle θ_H is :

$$\varepsilon_H = (x_T^2 + y_T^2 - R_0^2\cos^2\psi_H)^{\frac{1}{2}} - R_0\cos\psi_H(\tan\psi_H + \theta_H) \quad . \quad . \quad . \quad . \quad . \quad (29)$$

It follows from Fig. 12 that

$$\theta_H = \tan^{-1}\frac{x_T}{y_T} + \tan^{-1}\frac{(x_T^2 + y_T^2 - R_0^2\cos^2\psi_H)^{\frac{1}{2}}}{R_0\cos\psi_H} - \psi_H \quad . \quad . \quad . \quad . \quad . \quad (30)$$

The error ε_H will occur in the transverse basic rack of the hob at a height above the pitch line H_H, when measured from the hob side of the rack, where, from equation (11),

$$H_H = R_0\theta_H \sin\psi_H \cos\psi_H \quad . \quad . \quad (31)$$

Relationship Between Hob Form and the Profile Error of the Resulting Gear

Knowing the conjugate rack error in the section of the hob transverse basic rack, it can be shown from Fig. 11 that the corresponding error in the hob side of the gear transverse basic rack is ε_g occurring at a height H_H where

$$\varepsilon_g = \frac{\varepsilon_H \cos\psi \sin l}{\cos\psi_H \cos\sigma} \quad . \quad . \quad . \quad (32)$$

but the error in the transverse basic rack of the gear is

$$\varepsilon_z = -\varepsilon_g.$$

Therefore, from equations (29) and (32),

$$\varepsilon_z = -\frac{\sec\psi_H \sin l}{\sec\psi\cos\sigma}[(x_T^2 + y_T^2 - R_0^2\cos^2\psi_H)^{\frac{1}{2}} - R_0\cos\psi_H(\tan\psi_H + \theta_H)] \quad . \quad . \quad . \quad . \quad . \quad (33)$$

This error will occur in the transverse basic rack of the gear at a rack height H_z where

$$H_z = -H_H$$

and therefore from equations (11) and (31),

$$\theta = \frac{R_0\theta_H \sin\psi_H \cos\psi_H}{R_p \sin\psi\cos\psi} \quad . \quad . \quad . \quad (34)$$

The angle θ being the generating angle of that part of the gear tooth theoretical involute at which the error ε_z will occur.

It can be shown from equations (8) and (9) that the gear tooth polar radius ρ measured from the centre of the gear and associated with the generating angle θ is such that

$$\rho = R[1 + (\tan\psi + \theta)^2]^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad (35)$$

Hence, knowing the particulars of the gear, and of the hob, it is possible to calculate† values of ε_z and ρ for various values of ω.

Some Examples of Theoretical Profile Errors

The theoretical profile errors generated in a helical gear of 30 deg. helix ; 4 diametrical pitch ; 48in P.C.D., and 20 deg. transverse pressure angle, when machined by four different hobs, were calculated from the equations derived. The four hobs considered were :

(1) Straight-sided axial, $1\frac{1}{2}$ deg. pitch cylinder lead angle.

(2) Straight-sided in the normal section and $1\frac{1}{2}$ deg. pitch lead angle.

(3) Straight axial 2 deg. lead angle.

(4) Straight normal 2 deg. lead angle.

† From equations (25), (26), (27), (28), (30), (33), (34), and (35).

The resultant graphs of profile error against gear tooth polar radius are shown in Figs. 13

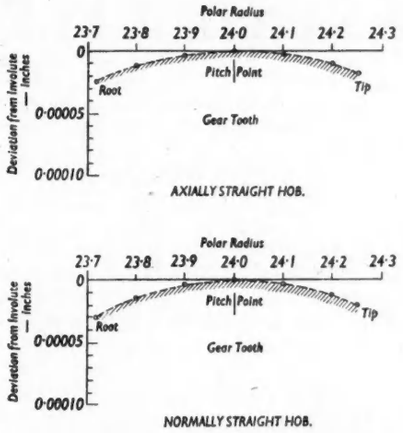


Fig. 13—Profile errors of a 4D.P. 48in P.C.D. gear when generated by a hob of $1\frac{1}{2}$ degree pitch lead angle

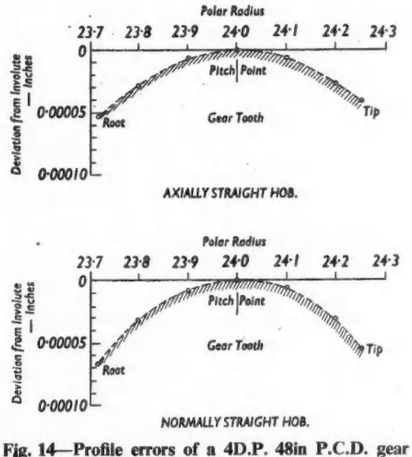


Fig. 14—Profile errors of a 4D.P. 48in P.C.D. gear when generated by a hob of 2 degree pitch lead angle

and 14. As previously stated, the involute helicoid hob is the only one which is theoretically capable of generating a perfect involute helicoid tooth form, so that, in each of the four graphs, the zero error axis represents the profile error as generated by an involute helicoid hob. It is evident that the profiles generated by normally and axially straight hobs are convex with respect to the theoretical involute ; that is, they inherently introduce a form of profile tip and root relief. From Fig. 13 it can be seen that the tip and root relief generated by a 4 D.P., $1\frac{1}{2}$ deg. lead, axially straight hob, is 2×10^{-5}in and $2{\cdot}5\times10^{-5}$in, respectively, whereas those of the same hob straight sided in the normal section are 2×10^{-5}in and 3×10^{-5}in. By increasing the pitch lead angle half a degree to 2 deg. (see Fig. 14), the tip and root relief introduced by an axially straight hob is $4{\cdot}5\times10^{-5}$in and $5{\cdot}5\times10^{-5}$in, and those of the normally straight hob are $5{\cdot}5\times10^{-5}$in and $6{\cdot}5\times10^{-5}$in.

It is therefore evident that a small increase in hob lead angle will produce a relatively large increase in tip and root relief, a normally straight hob always producing more relief than the corresponding axially straight hob. It is presumed both from the graphs in Figs. 13 and 14, and the two equations (27) and (28) that the difference between the gear tooth generated by normally straight and axially straight hobs will become more marked as the hob lead angle l, and consequently $-\chi$ increases.

Conclusions

Compared with the involute helicoid hob, with which it is theoretically possible to generate a perfect involute helicoid gear,‡ it is shown that hobs ground straight sided, either in the axial section or in a section normal to the pitch helix, introduce a form of tip and root relief into the transverse tooth profiles of the resulting gears. This relief is greater in the case of normally straight hobs and in those with the larger lead angles.

With single start, medium diametrical pitch hobs, of approximately 6in pitch circle diameter, the pitch lead angles and the tooth depths will be so small as to introduce no more than 1×10^{-4}in profile relief. However, for small diametrical pitch hobs (3 D.P. and less) of the same P.C.D., the corresponding lead angles ($2\frac{3}{4}$ deg. and more), and the larger tooth depths, should increase the tip and root relief to several ten-thousandth of an inch, especially when normally straight hobs are used.

As an extremely small amount of profile relief is required for helical gears because of their scissor action, it is recommended that gear tooth forms should be produced by normal or axially-straight hobs in preference to the relieved, or unrelieved, involute helicoid hobs. In the case of unrelieved involute helicoid hobs there would, in theory, be no profile relief at all in the resulting gears, and in the case of relieved involute helicoids it is extremely difficult to introduce any controllable small departure from the straight generator in the hob dedendum.

The author is indebted to his colleagues in the B.T.H. Research Laboratory, and to the Gear Engineering Department for encouragement and assistance in this work.

‡ That is, of course, subject to the small inaccuracies caused by the facets on hobbed gear tooth surfaces (Couling, 1943, 1949)

Fire Research

The Department of Scientific and Industrial Research has published its report on fire research for the year 1956. Surveys of the incidence and cost of fires are given in the report, together with accounts of researches to improve measures for preventing fires. The Fire Research Board points out that a more fundamental approach to the whole problem of fire protection has become necessary, and research is now aimed at providing a basis for such an approach. More precise evaluation of safety requirements is needed, the Board considers, not only to indicate where fresh precautions should be introduced but also to show where relaxations might be possible. In this way, the Board asserts, its research can make a substantial contribution to the national economy.

An operational research approach is being used to investigate outbreaks of fire. For instance, an analysis of fires in houses showed that one departure from traditional methods of construction was accompanied by an increase in serious fires, and the importance of the change was assessed statistically. A survey of the hazard through ignition of clothing has been started as part of this work.

Work in progress during 1956 included specialised researches into the growth of fire, tests on building materials and methods of construction, and work on fire detection and extinction. The committee on industrial fires and explosions " has made vigorous progress." Its experimental work has been devoted mainly to factors that influence the ignition and development of flame and pressure " build-up " in mixtures of air with dust or flammable vapours and gases, but no reports on that work have yet been prepared.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

CAMBRIDGE ARTS AND SCIENCE DEGREE

SIR,—The resourcefulness of the prophet was never so surely demonstrated as on that celebrated occasion that he went to the mountain, when the mountain refused to come to him. However, it seems that there are still students of the arts, who, being possessed of the faith that moves mountains, are convinced that the Everest of Science will come to them. Even D. A. Ogilvie, who criticised, in your issue of August 2, your editorial under the above heading, printed on June 28, seems prepared to go only halfway, and then carrying a banner with a strange device—a scales with the arts on one side and the sciences on the other. Education should not impart the ability to learn so much as the ability to think—that faculty that distinguishes us from the parrot. It is to be feared that a classical education may equip the victim with the beady eye and plumage of our feathered friend, more than it will impart the other much-to-be-desired ability. It is well to recall the lament of the late Dr. C. E. M. Joad that " it is nothing short of a scandal that, while our knowledge of life and mind grows yearly more astonishing, and the physical universe revealed by modern science is as fascinating as a fairy tale and as mysterious as a ghost story, young minds should still be drilled in the syntax of dead languages and young curiosities stifled by a dead weight of verbs and declensions."

It is pertinent to ask how many of those given a classical education still read Latin and Greek, and why do those that do keep so quiet about it ? The treasures that are revealed by such an education are tawdry stuff when set besides those of our own literature. What gems there are in the classics shine just as brightly in translations. It is a curious fact that while scientists are so often criticised for not being able to communicate the wonders of science, classicists are just as often complimented when they claim that the esoteric marvels of Greek and Latin can only be appreciated in the original and that translations and popular versions are inadequate at the best.

Again, Mr. Ogilvie does less than justice to your suggestion of the value of a study of British technology over the past 200 years. Considering how often the scientist and technologist is blamed for the social results of his efforts it is surely more desirable that the hazy stories of Crompton's " Mule " and Arkwright's " Spinning Jenny " be replaced by an understanding of the social implications of those years and of the great changes brought about by technology.

Modern civilisation can hardly be said to have fallen down in its technical achievements, rather has it failed in just those directions in which " cultural " and " classical " educations are held to be so valuable. May it not be because so many of our rulers and teachers would be more at home in dead and gone civilisations than they are in the twentieth century—at least that is the impression they strive to give.

It is strange that Mr. Ogilvie advocates teaching art and science side by side, let us rather tip the scales in favour of the sciences and not deliberately set out to produce those that would only be half educated. The saving grace, of course, is that whatever system we choose, there are those who will rise above it and prove the truth of the Irish philosopher's contention, " Sure, and one man's as good as another—and a great deal better ! "

CHARLES SIGSWORTH, M.Eng.

Walsall, Staffs,
August 16, 1957.

SPEED FACTORS FOR GEARS

SIR,—The short answer to Mr. Boomsma's concluding question in his letter published in your issue of August 2, is that speed factors for gears can be regarded only as elements in empirical rules for determining permissible loading. It would be an unwarrantable assumption that they are derived either from studies of the kinematics of gear engagement or of the physics of line-contact loading. From Barth to B.S., speed factors merely represent somebody's personal expression, in quantitative terms, of the notion that the higher the speed, the lower the stress should be. If the curve fits an algebraic expression, it is tempting to believe that it rests on a kinematical or physical basis.

The history of B.S. speed factors is as follows. Up to about 30 years ago, gear " wear " ratings were based on the assumption that the load-carrying capacity was proportional to $\sqrt{R_r}$ where R_r is the relative radius of curvature. The proposal that it be made proportional to R_r, on the basis of the classical Hertz analysis, was put into practice in association with an empirical speed factor which was a function only of gear speed in revolutions per minute. The result was that some gears in the larger sizes started to " pit " prematurely. As an arbitrary measure, the surface stress criterion was changed from $S_c = F_c/R_r$ to $F_c/R_r^{0.8}$ where F_c is the normal load per unit length of contact line ; but the speed factor based on revolutions per minute was retained. This seemed to give satisfactory ratings and was the design basis in use when B.S.S. 436 was first issued. As time went on, the speed-factor curve was modified here and there, but it was much later when I pointed out that it was approaching the form $X \propto N^{-0.2}$ and that almost the same results are given by a formula in which S_c reverts to the original value S_c/R_r and the speed factor is proportional to $V^{-0.2}$ where V is the pitch-circle velocity. The fact that the index of R_r, viz. 0·8, is equal to 1—0·2 (the index of N) which leads to this relationship was pure coincidence.

Although the change in the index of R_r was designed to favour larger gears at similar rotational speeds (and therefore running at higher pitch-circle velocities), it remains uncertain whether it acted to compensate for increased dynamic increment with increased pitch-circle velocity, or for possibly greater pitch or profile errors in larger gears, or whether its use was made necessary by uncomprehended physical phenomena associated with surface stresses *per se*, possibly in conjunction with the influence of the lubricant.

But tests on rolling/sliding discs, and on small, accurate gears running under laboratory conditions, give figures for pitting-resistance (in terms of $S_c = F_c/R_r$) much higher than experience shows to be safe with the larger types of industrial gear drive. The difference, contained in the speed-factor curve and the basic stresses for various materials, can therefore be regarded as containing an additional empirical factor which allows for other variables in cutting, mounting and operating conditions not yet susceptible to analysis. This factor is so large that quite different surface-stress criteria and speed factors might still give results which fit experience. After all, many other rating formulæ are in use.

More fundamentally, the assumption that allowable load is proportional to the product of two independent factors, one of which relates to a statically computed stress condition based on load and tooth geometry, and the other to speed, is highly questionable. Evidence has long been available (Meldahl 1935) that the slide-roll ratio considerably modifies the result ; and the simple-seeming criterion $S_c = F_c/R_r$ may have to be elaborated to include tangential friction and stress, temperature stress, thermal conductivity, oil penetration into cracks, and who knows what else. When these things are understood, the relationship between the physics of gear-teeth and of rolling bearings, to which Mr. Boomsma has referred, will be clearer than it is now.

H. E. MERRITT

Warwick,
August 13, 1957.

ACTIVITIES OF THE ENGINEERS' GUILD

SIR,—The leading article in your issue of August 9 gives welcome encouragement to the new policy which the Guild has recently announced, and indeed there can be no doubt that the engineering profession, collectively and individually, stands to benefit from the successful completion of these tasks. It is common knowledge, however, that many of those who complain most bitterly about the profession's lack of status in the community are most apathetic about taking positive action to change the present state of affairs, and this attitude, so damaging and so widespread, must inevitably hamper the Guild's efforts to achieve all of which it is potentially capable.

The Guild has never lacked " determination to take a more active part in line with the

objects for which it was created" ; what it has lacked is strength to its arm, and this is something which those who will be the beneficiaries of its present efforts have it in their sole power to provide. You rightly point out that "in carrying out the task it has set itself the Guild is likely to find itself assisted by other bodies deeply sympathetic to its aims," but in the last resort it is the assistance of individual professional engineers expressed through membership, which must determine how far, and how fast, the Guild progresses.

It is in the power of the members of the engineering profession to exert a strong collective influence on our national life, transcending the technical field, and those who take pride in the profession may well feel that such an influence is desirable in an age of technology. Any student of American affairs will know that such a position is no pipe-dream, but it can never be achieved under several banners, nor under none. My council believes that its new policy is realistic, progressive and ambitious. I hope that every engineer who read your article will ask himself whether he cares sufficiently about the future of his profession to support the Guild's work, and will act according to his honest answer.

J. G. ORR,
Secretary

Engineers' Guild,
78, Buckingham Gate,
London, S.W.1.
August 19, 1957.

Book Reviews

Polythene : The Technology and Uses of Ethylene Polymers. By A. RENFREW and P. MORGAN. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 126s.

THIS comprehensive handbook on polythene covers the whole field from the production of the raw material, ethylene, and its polymerisation to polythene to the properties, processing methods and applications. The additives used include colouring matter and anti-oxidants to prevent oxidation and deterioration on ageing. Weathering tests carried out show the necessity for incorporating these stabilisers, particularly for outdoor applications. Molecular structure and crystalline structure are considered, together with methods used for determining them. The effect of some processing methods on crystalline structure is considered as this influences some of the properties. The electrical properties discussed include dielectric constant, dielectric loss and dielectric strength. The effect of modification of the polymer and structure on these properties is considered. The mechanical properties discussed include stress-strain properties, creep properties, low-temperature flexibility and dynamic mechanical properties. The effect of temperature on these properties is shown. The chemical properties are considered under the headings chemical resistance, permeability to gases and liquids, absorption of liquids by polythene and environmental cracking. The effect of a large number of organic and inorganic substances on polythene at temperatures of 20 deg. and 60 deg. Cent. is shown in tabular form. Test methods for melt viscosity, tensile strength, environmental cracking, low-temperature brittleness, power factor, dielectric constant and resistivity are given. Some British and American specifications dealing with polythene and polythene articles are given. The effect of irradiating polythene with high energy radiation on its properties is considered. This treatment cross links the material so that it becomes insoluble and infusible. Modification of the polymer by chemical means to obtain a material more suitable for any particular application is considered. Processing methods are given in considerable detail, particularly the extrusion process for the production of cable covering, tube, rod and other profiles, lay flat tubing and film. The design of extruison machines is discussed at length with diagrams and illustrations, particular reference being made to the screw design and die design for particular applications. Injection moulding, centrifugal casting, paper coating and bottle production, particularly by blow moulding, are also considered in detail. Coating by spray coating methods and dip coating is considered and some particular applications of each are given.

Many applications of polythene for cable insulation are considered and the properties of the material which make it particularly valuable for this purpose are discussed ; some types of cable are illustrated. Some other electrical applications are mentioned. Polythene is also used in the form of film for many purposes ; these are considered with particular reference to packaging applications. Some particular properties of these packaging films are considered. Polythene piping is used in domestic and agricultural applications and also for industrial piping where corrosion resistance is important. Moulded polythene pipe fittings are used in this case. In the construction of chemical plant a considerable amount of polythene is used and fabricating methods are given with illustrations of some of the finished components. Domestic applications are also considered with illustrations. The production and properties of polythene filaments and the production of fabrics from these are considered. Applications of these fabrics and the material in the form of rope are considered. The future outlook in this country and in U.S.A. is given.

This is a book which should be kept for reference by all who may wish to use polythene in place of materials which are not entirely satisfactory as well as by those who already use it.

Instrument Technology : Vol. III, Telemetering and Automatic Control. By E. B. JONES. Butterworth's Scientific Publications, Ltd., 88, Kingsway, London, W.C.2. Price 40s.

A TEXTBOOK on such a subject as instrument technology must be selective in its treatment and it should be pointed out at the outset that this book is aimed at covering the ground required for the intermediate and final examinations in instrument maintenance of the City and Guilds College, London. The object has thus been to give a descriptive explanation of the workings of various control elements with as little as possible reference to the analytical mathematics.

The book starts with a chapter on telemetering where this is defined as the reproduction at a convenient location of measurements made at a remote point. Pneumatic and electrical telemetering systems are considered and the chapter is very well illustrated by reference to many actual systems. Various remote systems are described involving such things as G.P.O. transmission lines, but the telemetering example of data transmission as usually understood in aircraft and weapon work is not included. The second chapter starts with a discussion on what is called theory and which reduces to the definition and explanation of many of the usual terms employed and a discussion of the various types of control which are possible. Some examples of the type of response to be expected are also given. After this brief discussion on the theory of the subject the construction and operation of some of the simple self-acting process controllers is dealt with starting off with simple pressure controllers, level controllers and temperature controllers. Coming on to more complicated controlling units they are considered in two parts, the first part, which produces a signal proportional to the deviation, and the second part, which converts this deviation into a controller output signal which operates the correcting unit. Detailed consideration is given to the pneumatic controller with an interesting section on the attainment of various forms of control in a pneumatic system. A series of actual controllers are illustrated diagrammatically and described in sufficient detail to indicate how exactly they operate. Considerable detail is gone into in the consideration of choice and operation of valves in pneumatic systems and various practical valves are considered. This is followed by a brief description of auxiliary equipment for use with pneumatic controllers and then some useful instruction on installing, adjusting and maintaining a controller.

In the remaining few pages a very cursory examination is given of, first, hydraulic, and, subsequently, electrical and electronic controllers, the shortness of the treatment being, no doubt, due to the fact that these controllers are not as yet so common in industrial processes, although much more common in some form of automatic control. This is presumably included to accommodate the syllabus of the City and Guilds.

This is an interesting and well-illustrated book and does, no doubt, meet its primary object of instruction for City and Guilds examination. For the practising engineer who wants a factual description rather than a precise analysis, it should also prove very helpful. The layout, however, was found to be somewhat confusing and much more chapter headings could easily have been provided.

Books Received

Vector Analysis. By Louis Brand. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 48s.

Physical Optics. By R. A. Houstoun. Blackie and Son, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 40s.

Effective Industrial Management. By James L. Lundy. The Macmillan Company, 10, South Audley Street, London, W.1. Price 44s.

Top-Link Locomotives. By Norman McKillop. Thomas Nelson and Sons, Ltd., 36, Park Street, London, W.1. Price 12s. 6d.

Receiving Aerial Systems. By I. A. Davidson. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 21s.

Regime Behaviour of Canals and Rivers. By T. Blench. Butterworths Scientific Publications, 88, Kingsway, London, W.C.2. Price 30s.

Instrumentation in Testing Aircraft. Volume V. By C. N. Jaques. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 45s.

Project Engineering of Process Plants. By Howard F. Rase, and M. H. Barrow. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 114s.

Surveying : Elementary and Advanced. By William Horace Rayner, and Milton O. Schmidt. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 63s.

Engineering Thermodynamics. By C. Osborn Mackey, William N. Barnard, and Frank O. Ellenwood. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 64s.

Soil Mechanics Conference

THE fourth international conference on soil mechanics and foundation engineering was in progress last week and until Wednesday of this week at the Institution of Civil Engineers. This article comprises a very brief review of the technical work of the conference. Last week, we commented upon the conference generally, and gave some details about it, and we have also included in this issue an account of the exhibition which accompanied it. Previous conferences were held at Zurich in 1953, at Rotterdam in 1948, and at Cambridge, Massachusetts in 1936.

In his opening address, Sir Arthur Whitaker gave some idea of the scope and importance of the conference. Twelve hundred delegates from forty-one countries atttended it, and 176 papers were published in the two preliminary volumes and presented for discussion. The British organising committee, however, originally received about 350 notifications of papers, and because of such an overwhelming response it became necessary to limit the number of papers which each national committee could submit. Obviously, with about half of the original suggestions rejected, and the remaining papers written as briefly as possible, the standard of the papers presented is very high, and there is much original work of great value to be found in them. The following account can only hope to give a somewhat fragmentary review of all this work. The general reporters of each section, however, indicated the trends of development and the problems for which solutions were most urgently needed, presented as "suggestions for discussion," and in the following sections we have drawn from their remarks. The headings correspond to the classification of the congress's work.

The Fundamental Science

Those papers in division I of the congress fell under the heading of "Soil Properties and Their Measurement," but the division was subdivided into two, dealing respectively with general and scientific aspects, and with engineering and mechanical aspects. In the first subdivision, the fundamental properties of soil materials were investigated.

A number of authors devoted themselves to geological and regional topics. For instance, there were accounts of the properties of Indian black cotton soils, of the Leda clay found in the Ottawa region, and of Negev loess. Other authors, however, concentrated on fundamental theory. The general reporter, Professor Rosenquist, of Oslo University, considered that the lack of mutual knowledge of the wofk of other scientists, particularly where researches bordered upon chemistry, physics and mineralogy, was striking. A common feature of the theoretical papers was the consideration of the behaviour of water in soils, and he thought that if the conference could arrive at a clearer understanding of the physical principles controlling the water present in fine-grained soils it would be of importance.

In the second subdivision of division I, experimental and theoretical investigations were recorded, dealing with shear strength and compressibility of soils and advances in detail were recorded of methods of carrying out basic laboratory tests and the ranges of validity over which they applied.

Tests in the Field

Techniques of field measurement and sampling formed the subject of the conference's division II, nine papers being presented. It was pointed out that no major development had been made in the various techniques of soil exploration and sampling or in the in-situ measurements of permeability, water and earth pressure, settlement and deformation, since the previous conference. Field investigations for engineering projects had, however, been made easier by advances in photography and geophysical exploration carried out from the air. These points were made by the general reporter, Professor Milton Vargas, of Sao Paulo University; nevertheless, a paper on aerial reconnaissance was not presented to the conference. Professor Vargas also called for a degree of standardisation in the design and usage of testing apparatus.

Foundations of Structures

About a third of the papers presented to the conference dealt with topics within the scope of division III, on foundations, which was subdivided into (*a*) general subjects and foundations other than piled foundations and (*b*) piling and piled foundations. In the first category, no revolutionary new discoveries were included, but the papers were evenly divided between theories, tests and case records, and revealed a steady progress towards better understanding of soils and greater assurance in foundation design.

There is still much empiricism in foundation design, and the use of piles remains one of the least rational and most empirical subjects, to which the procedures of soil mechanics have been applied only in the last few years. The conference papers on piles and piling concerned, first, bearing capacity of piles in sand and in clay respectively. Five papers on bearing capacities in sand added new knowledge. It was considered that a growing reliability was shown in the prediction of load capacities of piles embedded in sands or with a good penetration into a granular bearing stratum. But the opposite view was stressed for piles driven in clay. Special interest was shown in the problem of buckling of long, slender piles driven through soft soils, and the bearing capacity of groups of piles was also discussed.

Turning to individual contributions in the section on piling, Zeevaert reported an unusual and daring use of friction piles driven into clays for the purpose of reducing settlements. The building in question is in Mexico City on the deep and highly compressible clay deposits familiar to all engineers who have studied soil mechanics. It was not considered feasible to support the building on piles driven to a sand stratum at a depth of 42m or to excavate a weight of soil equal to the total weight of the building. Therefore, a design was selected in which the weight of the excavated soils was approximately 75 per cent of the weight of the building and widely spaced friction piles were driven to penetrate only through the upper and most compressible of the clay strata. The piles were driven after partial excavation of the foundation and " had the purpose of reinforcing the clay deposits between 6m and 24m in depth and reducing expansion during excavation and re-compression of the highly compressible clay in the total length of the piles." The piles were designed on the basis that only that portion of the weight of the building not compensated for by excavation would be carried by the piles. On the design basis the load per pile was 26 tons but under the total weight of the building the load per pile would be 96 tons.

Zeevaert included settlement observations on the structure up to a time of eight months after completion of loading, which showed remarkably close agreement with computed settlements based on the design assumptions. The general reporter, Mr. P. C. Rutledge, of New York, considered that the reported results might not represent the ultimate answer on the performance of this design.

Barkan discussed extensive work done in the Soviet Union on the vibratory driving of piles and the effects of variables such as frequency, amplitude, eccentric moment and ratio of vibrating to static weight on the frictional and point resistance of piles. Vibration driving was most effective in overcoming the frictional resistance of sands and high amplitude vibrations were necessary to overcome the point resistance. In view of these factors, vibratory driving of steel sheet piles seemed to be the most practical application of this procedure. Apparently, vibratory driving and extraction of steel sheet piles has been widely applied with much success in the Soviet Union. Barkan stated that both light and heavy sections of sheet piles had been driven to depths of 14m to 16m in saturated sands cutting through medium strength clay strata up to 4m thick. The vibrator used for this driving had a speed of 800 r.p.m., an eccentric moment of 3000kg cm or about 300ft lb, and an unbalanced force of about 20 tons with an amplitude of 8mm to 10mm. The total weight of this vibrator was 1·8 tons with maximum motor output of 28kW. It was claimed that penetration of sheet piles under such driving reached a speed of 10m per minute, that as many as fifty-three sheet piles 16m long were driven per shift and that the sheet piles could be extracted in an undamaged condition for re-use.

Mr. Rutledge pointed out that it was entirely logical that high frequency and low energy impacts, as compared with pile driving hammers, should be successful in driving sheet piles in which interlock and skin friction were major factors in resistance to driving. He considered that manufacturers of constructional plant and contractors in all parts of the world would do well to investigate the possibilities of driving and extracting sheet piles with vibratory equipment. The potentialities of vibratory driving for piles and for soil sampling equipment were, he believed, considerably less attractive, although high-frequency low amplitude vibration in conjunction with rotary drilling had worked well in rock drilling and coring operations.

Roads, Runways and Permanent Way

The specialised branch of soil mechanics devoted to roads, aircraft runways, and permanent way had, in the opinion of the general reporter Monsieur R. Peltier, research director of the Ponts et Chaussées central laboratory, made rapid progress since the 1953 conference. The papers presented covered only a small part of the subject. Improvement had been especially noteworthy in the compaction of soil. New, heavy, vibrating apparatus was available and experimental progress had been achieved. New methods of testing bearing capacity were being developed, and chemical stabilisation of soils had also developed markedly and would continue to do so.

Earth Pressures

Theory and practice in the evaluation of earth pressures and of their action on sheet-piling, cofferdams, excavations, tunnels and silos were dealt with in division V, and a general report was submitted by Professor J. Kérisel of the Ecole Nationale des Ponts et Chaussées. Some reasonably accurate ideas were now evident, he considered, concerning the action of passive earth pressure. But a knowledge of local distribution of earth pressure behind structures was less advanced, because of their flexibility and displacement, except in the case of steel piling due to the researches of the British engineer Rowe.

One of the subjects investigated by British contributors to this section of the conference was that of the stresses in old tunnels of the London underground railways. Messrs. Ward and Chaplin of the Building Research Station commented upon measurements, made with vibrating wire gauges, of circumferential stresses in the cast iron linings of these tunnels. The average stresses in the " skin " of the linings were in reasonable agreement with the stresses due to hydrostatic overburden, but where adjacent tunnels were less than a diameter apart, the flange stresses in the earlier tunnels could be tensile, and were dominated by the effects of excavating the later tunnel, effects which were simultaneous with excavation and persisted for at least 50 years. The sequence of excavation and construction of tunnels at one site could be established quite clearly from the stress measurements, taken half a century later. The consistency of stress distribution in consecutive rings was considered quite remarkable.

Earth Dams, Slopes and Open Excavations

In this last section of the congress—division VI—there were papers on natural slopes, including accounts of landslides, an investigation of permissible slopes for a large excavation in weak clay (permissible slopes from 4 to 1 to 10 to 1 were ascertained) and several papers on the

construction of dams and embankments, and on measurements from existing dams. There were also papers on soil properties and analytical procedure.

The wide variety of materials which can be successfully used for embankment construction was pointed out by the general reporter, Mr. F. C. Walker, of the U.S. Bureau of Reclamation; questionable foundations were a principal source of difficulties, because of variability within the zone of influence, and of uncertainty of test results matching actual conditions. A new development was to depart from normal methods of specifying safety, and substitute an evaluation based on "minimum probable conditions," with some qualification. The general reporter questioned the adequacy of terminology at present used for describing soil structure, and also the concept of "cohesion." If "cohesion" were considered as the product of internal normal stress and the coefficient of internal friction, he asked, could a simple rigorous mathematical solution to problems of embankment stability be found?

The division included several interesting papers on earth- and rock-fill dam construction. One of them, by Messrs. Schiltnecht and Bickel, described the theoretical work behind the Castilletto dam in Switzerland (described in THE ENGINEER of May 21, 1954) in which "glaciae flour," a non-plastic clay-sized soil was used for the embankment core.

Exhibition of Soil Mechanics and Civil Engineering

THE conference which formed the subject of the preceeding article was held at the Institution of Civil Engineers, and while it was in progress an exhibition, covering substantially the same range of activities as the conference itself, was on view in the Institution building. In contrast to the conference, however, the exhibition was British in character, and it gave a good idea of recent British practice in the use of testing apparatus and procedures, and achievements in actual construction, principally in cases where the techniques of soil mechanics play a prominent part.

In the ensuing notes we have selected one or two of the exhibits for brief description. The exhibition was fairly comprehensive, and included displays of the activities of large contracting organisations, exhibits of laboratory testing apparatus, and of gear used for soil testing and core drilling in the field. Specialist firms also exhibited, showing, for instance, various proprietary systems of piling and plant such as piling frames.

Quoich Dam

One exhibit, shown by the consulting engineers, Sir William Halcrow and Partners, dealt with the North of Scotland Hydro-Electric Board's dam in Glen Quoich, Inverness-shire, which impounds the headwaters of the River Garry for generating electricity. This dam is notable as the first large rockfill dam in Britain to be built with a watertight membrane of reinforced concrete on the upstream face instead of the more usual core wall. The dam is 1050ft long at the crest and 126ft high at its deepest section. Details of its design and construction were published in THE ENGINEER of October 5 and 12, 1956. The following additional information is now given.

The dam stands on Moine schists and granulites, but the rockfill used for the dam consists of granulites only. Most of this material was quarried, but about 25 per cent came from tunnel and open excavations. The rockfill was placed in layers 2ft thick and each layer was compacted by rolling twice, first with a 10-ton smooth roller, followed by sluicing with water, then with a 4½-ton vibrating roller, again followed by sluicing. This system resulted in the compacted fill weighing 115 lb per cubic feet and having 31 per cent voids. During construction a uniform compaction occurred of about 0·7 per cent of the depth placed and there has been no measureable settlement since completion in May, 1956.

Analysis of an Unstable Foreshore

An investigation into subsoil conditions on the eroding West Shore at Fleetwood, Lancashire, was demonstrated on a display panel shown by the consulting engineers, Messrs. Lewis and Duvivier. Coast protection works have been necessary on this coast to prevent encroachment and the inundation of low-lying land by the sea for more than a century. The existing mass concrete sea walls over a large part of the frontage were constructed in 1927–28 and were founded on an alluvial clay bed generally at level +13·5 O.D., with coping level 26·0 O.D. The tidal range at spring is about 29ft. A profile of this wall showing the beach level at the time of construction and the underlying strata as revealed by recent borings was included in the exhibit.

Because of continued erosion of the silts and clays in front of the wall a steel-sheet-piled concrete apron was constructed as a protection to the foundation of the wall. During a storm in December, 1954, the relatively shallow layer of sand and shingle was swept away from in front of a long length of the apron exposing the underlying silts and silty clays which were rapidly liquefied. During the period of one tide the surface level was eroded practically to the toes of the sheet piles, causing the collapse of the apron and breaching of two long lengths of sea wall.

Photographs included in the exhibit showed one of the breaches during the following low tide with the foreshore level reduced nearly to Ordnance Datum (about half-tide level), and further cut-out profiles illustrated the influence of foundation conditions on this failure. While emergency repairs to the breaches were in hand a subsoil investigation covering the whole of the West Shore, nearly 3 miles in extent, was carried out, which included the drilling of forty-seven bore-holes, generally between 10ft and 50ft deep, sited behind the existing walls, immediately in front of the aprons, and 250ft seaward of the walls. The longitudinal geological sections included in the exhibit were prepared after examination and mechanical analysis of undisturbed samples from the bore-holes, and on these sections lengths of the sea walls and aprons considered from the nature of the foundation strata to be potentially dangerous or unstable were indicated.

A third profile indicated the measures taken in these potentially dangerous lengths, namely, a second emergency (stage B) apron to safeguard the works against a recurrence of the events of December, 1954, followed by a further (stage C) apron constructed at a low level at which it is judged that the silty strata can be stabilised against further scour and a covering of sand or gravel retained by groynes.

The consultants consider that an investigation on these general lines is applicable to any site at which the engineer is faced with the thankless task of constructing and maintaining a line of defence against encroachment by the sea on a foundation that is basically unstable and treacherous and in which the sole protection of the clay or silty substratum against erosion consists of a thin and intermittent beach of gravel or sand.

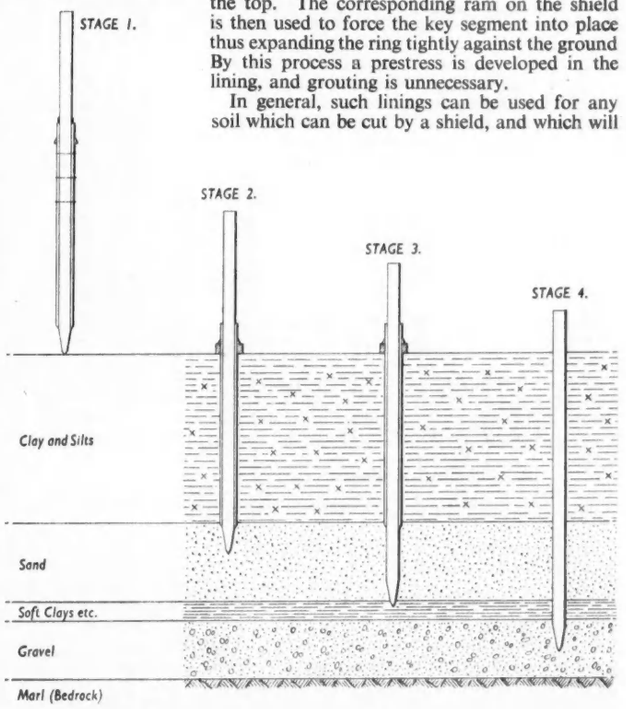
"Wedge-Block" Tunnel Linings

A model of one ring of "wedge-block" tunnel lining which is used for shield-driven tunnels in cohesive strata was shown by the Metropolitan Water Board. The lining is made from precast concrete blocks which are unreinforced, and no bolts are used during assembly. It will be recalled that an earlier design of lining using the same general idea—the "Donseg" lining—was first used by the Board and was described in this journal some years ago.

Each ring of the "wedge-block" lining consists of one key segment whose longitudinal faces are tapered to form a wedge, two side segments each with one longitudinal face tapered to match the key, and nine untapered segments. The lining has been used for tunnels of between 8ft and 9ft internal diameter, when the ring was 5½in thick. To erect a ring, the blocks are first placed against the cylindrical surface cut in the ground by the shield, the key segment being at the top. The corresponding ram on the shield is then used to force the key segment into place thus expanding the ring tightly against the ground By this process a prestress is developed in the lining, and grouting is unnecessary.

In general, such linings can be used for any soil which can be cut by a shield, and which will support itself while the rings are being erected, the ideal soil being a firm or stiff clay. The lining has been developed primarily for water pressure-tunnels driven through stiff clays. The surrounding clay prevents leakage, and the lining, together with any secondary internal fittings, remains rigid as long as the internal water pressure is insufficient to remove the stress in the lining.

Tests have been carried out (see THE ENGINEER, February 25, 1955) to measure the amount of hoop thrust developed under various conditions with the object of building tunnels with a controlled prestress in the lining. The magnitude of the prestress is determined from the water pres-



Stage 1: pile pitched ready for driving, jetting and driving commence simultaneously; load binders are removed as they near ground level.
Stage 2: pile driven down to position where jetting channels just enter the sand bed. At this stage the channels are locked against further vertical movement by timbers placed below the arrester brackets; the top through bolts and stop plates are also removed.
Stage 3: driving proceeds and the vertical movement of the pile causes the removal of the sealing plates on the jetting channels, thus leaving the shafts free for discharge of sand and water.
Stage 4: the pile toe, having passed through the sand beds, the jetting channels are withdrawn for re-use and the pile is driven to set in the normal manner.

Procedure for driving pile with jetting apparatus

sure which the tunnel is required to carry. Hoop thrusts are measured by pairs of vibrating wire load gauges built into special segments during erection, as was shown in the model, and readings are taken by an electronic oscillator. The gauges are waterproof and readings can be taken from ground surface when the tunnel is full of water.

The "wedge-block" tunnel lining has been used on a short length of one of the Board's tunnel mains at present under construction. It is to be used for the inlet and outlet tunnels of the Walton reservoir where water will be carried at a head of about 45ft above ground level and 180ft above tunnel axis; construction of the Walton tunnel is due to start this summer. The exhibit also showed the micrometer equipment for measuring changes in the diameter of the lining, and typical experimental results.

Ffestiniog Pumped Storage Project

The Central Electricity Authority's pumped storage scheme at Ffestiniog in North Wales, envisages a power station which will contain four pump sets, each of 75MW. Work is to start on site this autumn and the first set is expected to be commissioned in August 1961. The scheme is of large capacity, compared with other pumped storage schemes designed up to the present, and will probably be the first large scheme of this kind to be completed in this country. It is interesting to refer in this context to the recent publication of the North of Scotland Hydro-Electric Board's pumped storage scheme at Loch Awe (THE ENGINEER, July 26 last), which is designed for a pumping installation of 400MW.

For economical pumped storage two reservoirs are required within a reasonable distance of each other, but with a considerable difference of level. At Ffestiniog, the upper reservoir is to be formed by the construction of a massive buttress dam 100ft high and 900ft long to raise the level of an existing lake in the mountains, Llyn Stwlan. The top water level of the new reservoir will be 1650ft O.D.

The lower reservoir will be formed by a gravity dam with a maximum height of 70ft and 1800ft long across the Afon Ystradau at Tan-y-Grisiau. The power station will be on the west bank of this reservoir, which will have a top water level of 618·5ft.

Water from the upper reservoir will pass through intake towers constructed inside the reservoir near the upstream face of the dam and thence down two vertical shafts 700ft deep and 14ft in diameter. At the base of each shaft there is a vertical bend, and each bifurcates into two tunnels running at a slight gradient for 4000ft until the tunnel portal is reached. From the tunnel portal to the power station four steel penstocks of 8ft diameter will carry water to each of the Francis turbines of 105,000 h.p. The station will generate electricity for supply to the grid daily for about four hours during peak load periods and will consume power by pumping each night. A model of the scheme was exhibited by Messrs. Freeman, Fox and Partners.

Diamond Drilling

Soil mechanics investigations, such as drilling for test cores in fairly soft or friable materials, often make use of diamond drilling plant. Such applications have differing requirements than those for drilling hard rock, and several of the improvements introduced into diamond drilling practice over the past few years have aimed at facilitating this class of work.

One firm showing diamond drills at the exhibition was Triefus Industries, Ltd. The firm recently added to its stock a coring bit for applications such as those just mentioned, where air is used as a flushing medium. The aim is to avoid any tendency to damage the core by the flushing medium. Extra holes have been incorporated in the matrix, to give a larger flush of air, and less possibility of "blocking-off" and building up air pressure. The large protrusion of diamonds combined with an angled face, assist in preserving the core by deflecting the air outwards. Holes for the air flush are set in pairs in the matrix of the bit; these large cut-outs have been achieved without unduly impairing the strength of the matrix.

A more novel improvement, also intended for similar work, is the firm's "pump" reamer. A reamer is frequently employed behind a diamond drill, to keep accurate "gauge"; some reamers have a continuous ring of cutting material, others a number of strips. In this case, the strips are shaped spirally in a manner analogous to the blades of an axial-flow pump. Thus the reamer assists, by a "pumping" action, the removal of sludge from the drill bit, enhancing penetration rate and cleanness of the core. The reamer has a matrix of the tungsten alloy normally used for the drill bits; the stones are set in this matrix to give a taper from the bit diameter at the leading edge of the reamer to the "clearance" diameter at the trailing edge. The strips are milled with a coarser pitch at the leading edge. There are four to twelve of these spiral strips on the reamer according to its diameter. Its hydraulic action is satisfactory when air, mud or water are used as the flushing medium.

The Australian associate of Triefus Industries, Ltd., has recently developed, in conjunction with the Australian coal authorities, a split core barrel which enables an examination of the core to be made while it is still in the barrel. This device is to be made by the British parent company.* According to experience with this split barrel in the New South Wales coal measures, 95 per cent of core can be recovered, and an examination of the core in the barrel itself permits accurate plotting of the strata thus revealed. This is considered to be a major advance, for a core which has been pushed out of the barrel is often badly fragmented and makes positive identification of geological structure somewhat conjectural unless the core is in rock hard enough to withstand such treatment. The split barrel can be used with standard drilling gear, and can be inserted at those depths where detailed information is especially sought. The inner tube of the barrel is split, and is held along its length by lugs. The split inner tube is carried on a ball-race mechanism which permits rotation of the outer tube of the barrel, while the split tube remains stationary.

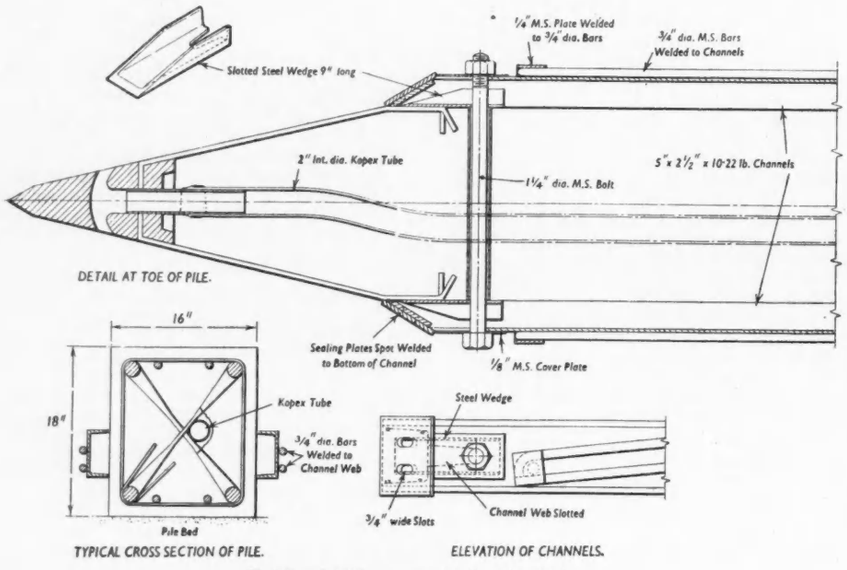
* We are asked to state that the firm has applied for patents covering the split core barrel and the "pump" reamer.

Jetting Attachments for Piles

The accompanying drawings show a system of piling developed by L. G. Mouchel and Partners, Ltd., for use in ground conditions where jetting is advantageous, but would normally be impossible because of an upper bed of clay. The strata are shown in the diagrammatic sequence of piling operations. The clay bed prevents jetting a pile through the sand below it, since water and sand cannot escape upwards through the clay. Piling then becomes extremely slow and difficult, and has involved heavy punishment of the pile and the driving equipment.

So the additional equipment shown in the drawing has been fitted to the pile to provide effective escape channels through the clay. Jetting is then employed, and the pile can be driven relatively speedily and with comparative ease. The piles used in this particular case were of 16in by 16in cross section for lengths up to 70ft and 18in by 16in when over 70ft in length. The same jetting arrangements served for both sizes.

The two drawings and the explanation in the legend clearly indicate the manner in which the equipment works. Above ground, the channels are secured to the pile by "load binders," which are successively removed as driving proceeds. Lengths of channel section are connected together with fishplates and a single bolt. An arrester bracket is also bolted to each channel, and is held by timber blocks at the appropriate stage of driving. The channels are slotted at intervals, as are the sealing plates shown on the detail of the pile toe. At the top of the pile, the assembly is held by a bolt passing through the pile and extracting brackets are bolted to the channels so that they can be taken out and used again.


Slotted Steel Wedge 9" long
¼" M.S. Plate Welded to ¾" dia. Bars
¾" dia. M.S. Bars Welded to Channels
2" Int. dia. Kopex Tube
1¼" dia. M.S. Bolt
5" x 2½" x 10·22 lb. Channels
DETAIL AT TOE OF PILE.
16"
18"
Sealing Plates Spot Welded to Bottom of Channel
⅛" M.S. Cover Plate
Kopex Tube
¾" dia. Bars Welded to Channel Web
Pile Bed
Steel Wedge
¾" wide Slots
Channel Web Slotted
TYPICAL CROSS SECTION OF PILE.
ELEVATION OF CHANNELS.

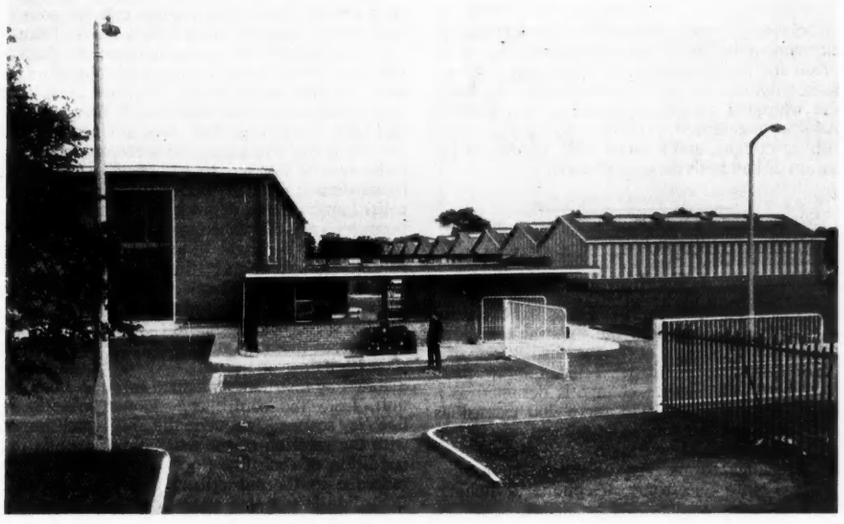
Details of jetting apparatus for pile driving

VEHICLE LIFE.—A Leyland "Beaver," which had completed 510,000 miles without the gearbox, differential or engine being opened, recently had its engine inspected. The maximum cylinder bore wear was 0·008in and gudgeon pin maximum wear on the worst pin was 0·00075in. Pistons were still in a clean condition, a thin skin of hard carbon covering the crown, top land and area on the gudgeon pin axis. There was practically no restriction at all in any of the holes at the base of the ring grooves, nor in the slots of the top and bottom scraper rings. Some of the ring grooves had slight wear. Examination of the big-end journals and bearing shells revealed a maximum ovality of 0·00025in. The soft indium coating was still intact on all the bearings, which were still serviceable. Of the main bearings, the intermediate and front bearing shells had worn only to the extent of showing the copper lead through the indium coating on the bottom halves of the shells for a circumferential length of up to 1in. The bearing clearances, measured with lead wire at the point of maximum wear, were 0·006in for the first main bearing, and 0·007in for the four intermediate bearings. All valves were seating perfectly and the seats were free from pitting. Wear on the stems was only 0·0005in on some of the inlet valves, one valve having a maximum of 0·003in. Wear on the exhaust valve stems was a little higher and varied from 0·001in to 0·007in. Noteworthy features of the engine were its complete freedom from dirt, scoring or abrasion, and the remarkably even polished wear that had occurred on all cylinders and bearings. The main contributory factors to these results appear to have been the use of a Supplement I engine oil, frequent changing of the oil, renewing the lubricating oil filter cloths every 3000 miles, and maintaining the engine air cleaner in a clean condition. A complete service set of fuel injectors had also been fitted when any injector faults were suspected on the engine.

Compositions Factory

Flexible and particularly the rubber adhesives are being increasingly used in a large number of industries, and to meet the expanding demand the Dunlop Rubber Company, Ltd., has built a new factory for its Compositions Division. The plant, which was opened recently, is at Castle Bromwich with a frontage of 300 yards on the Chester Road and has a present capacity of 2,000,000 gallons per annum.

EXPANSION in the demand for, and the extension of the application of, adhesives has resulted in the need for increased space to house the Compositions Division of the Dunlop Rubber Company, Ltd. To meet this need the company has built a new factory at Castle Bromwich, which has a frontage of 900ft on the Chester Road and extends to a depth of 500ft to the perimeter fence of the main Fort Dunlop factory. The buildings were officially opened on July 24 and consist of factory, boiler house, offices, laboratories, maintenance shop, finished and raw materials stores. In the photograph which we reproduce the offices and laboratories are to the left, with the factory building in the background to the right. The factory has a production capacity of 2,000,000 gallons of adhesives a year and an extension is already projected to house the plant for the manufacture of latex compounds and reclaim dispersions, having a capacity amounting to 1,750,000 gallons per annum. It is not intended that the 1,500,000 gallons per year "Polimul" plant should be transferred from its present site at Fort Dunlop.



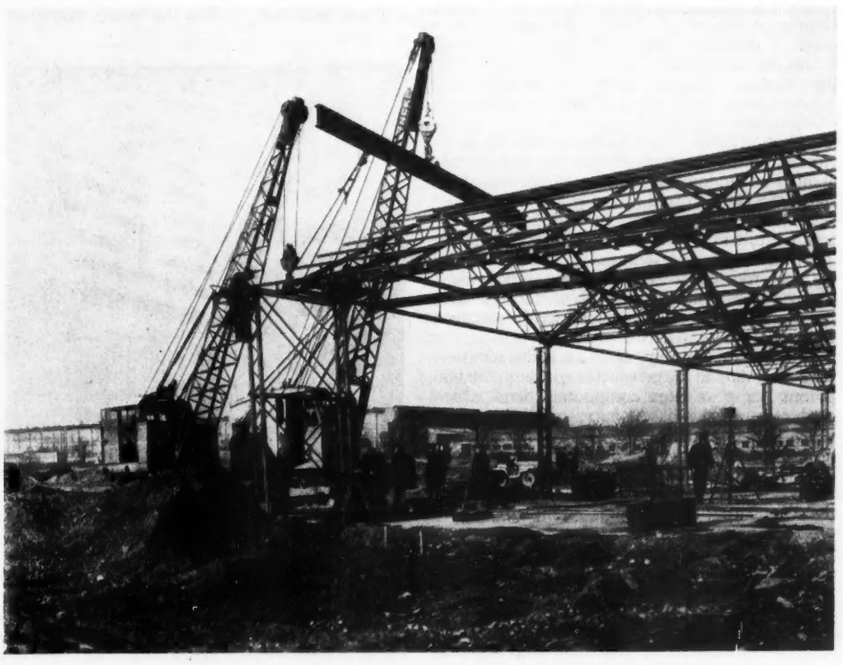
North elevation of the compositions factory, showing office block to the left and the factory to the right

The main factory building, which is sited in a north-to-south position, measures 360ft by 90ft and is designed so that extensions can be made to each end to house additional plant as required. At present the building is divided into three sections, one for incoming materials, another for finished goods store, and the main production area, amounting to 21,600 square feet. Ancillary buildings for the production control offices, laboratory and switchgear, are located on the west side of the production shop, while on the same side there is an underground tank farm for solvents. Outside the foundations for the machines, the floor of the factory consists of 6in of reinforced concrete with a stone-like finish. The floor level in the finished goods area is 1ft 3in below the main floor and so provides a sunken area sufficient to contain the contents of the full drums and avoid any flow back of adhesives into the production area in the event of a fire occurring. The outer walls have a 9in brick dado 4ft high, and are clad and lined by asbestos sheeting. The main structure is of tubular steel, supplied by Tubewrights, Ltd., and the method of constructing the roof is of particular interest. As already mentioned, the building is 360ft by 90ft, the whole area being free from support columns, and the tubular steel members of the roof were welded together on the factory floor in bays measuring 90ft by 40ft. These were raised, as shown in the accompanying illustration, on to perimeter stanchions by mobile cranes, there being a clear height of 16ft to the valley, and the whole roof was lifted into position in three days. The roof is clad with Anderson aluminium decking, including ½in insulation board and three layers of bituminous felt, and each bay is ventilated by four stack ventilators.

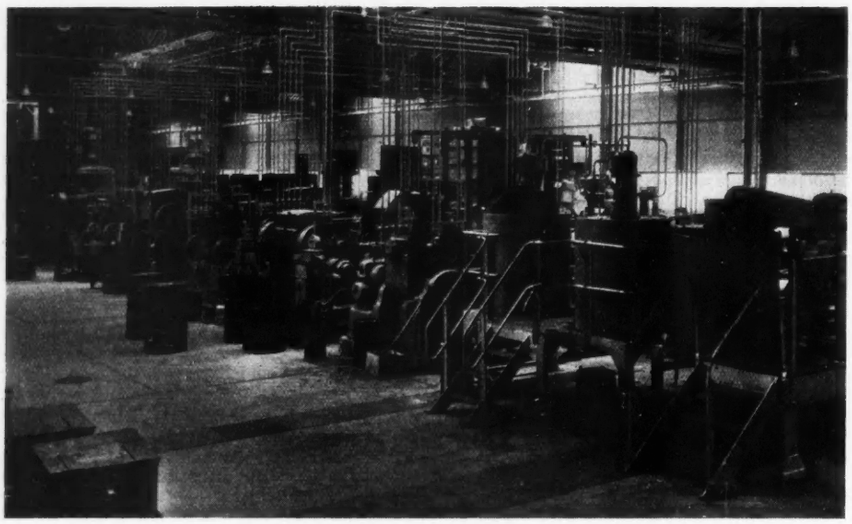
Linked to the factory by the canteen and kitchens is the two-storey laboratory and office block, which is a steel-framed structure having precast concrete floors and an external finish of buff blended facing bricks. The roof is of timber and the floors are finished with Semtex vinyl tiles and Semtex "Fleximer" flooring. There is a total floor area of 10,800 square feet divided by glazed partitions to form development laboratories and pilot plant on the ground floor, and offices on the first floor. A neutralising treatment tank deals with effluent from the laboratories and pilot plant previous to discharge into the drainage system. To the south of the production building are the boiler house, engineering shop and cooling water reservoir of 80,000 gallons capacity. There is a Daniel Adamson super-economic oil-fired, two-furnace boiler with a rating of 18,000 lb per hour at 100 lb per square inch using Laidlaw Drew oil fuel equipment. A compressor provides the necessary compressed air for the various services and two pumps deliver the cooling water from the reservoir to the machines: another pair of pumps return the water, which passes through a "Visco" forced draught cooler on its way to the reservoir.

Heating is by overhead steam pipes in association with a radiant panel, and fire precautions consist of a sprinkler system, generally with foam points at the machines. Fire-proof doors and roller shutters and flameproof lighting and switches are fitted, while the transport services are maintained by flameproof diesel trucks. In the factory is a battery of six mixing machines, each of approximately 120 gallons capacity, driven by electric motors through hydraulic couplings and having water cooled bodies and covers. The raised service gangway has hinged sections which are raised by hand-operated levers and a link system to allow the mixers to be emptied. In the centre of the space is the solution manufacturing plant, which can be seen in our illustration. Apart from a comprehensive battery of filling and sealing machines, there is a breaker mill and two sheeting mills for dealing with mixed rubber before it is placed in solvent-filled steeping boxes for softening. Mounted on a flat outside the factory is a solvent reclamation plant, the solvent fumes being exhausted from the machines by fan.

The adhesives, the production of which will attain a level of 2,000,000 gallons a year, have a common characteristic in that they are all of a flexible nature based upon natural and synthetic rubbers and natural and synthetic resins. The main industries served by the group include those concerned with motor-car and coach-building; building and flooring; textiles; boat-building; aircraft; and packaging, to which can be added many applications in light industry. Many formulations are currently in use and in



Cranes lifting 90ft by 40ft sections of the tubular steel roof structure



Solution manufacturing plant at the Dunlop compositions factory

the adhesives laboratory research work is directed to the testing of present techniques and products and to formulating new products to satisfy specified service conditions. Typical of the work carried out in the laboratory is the testing of latex dipping compounds used in the manufacture of fabric-lined gloves ; the measurement of the pile-locking efficiency of latex compounds for backing tufted and pile carpet ; a creep test on a woodwork adhesive based on a polyvinyl acetate solution ; the measuring of the adhesion strength of motor-car trim adhesives ; the assessment of flow characteristics of particular plastics; and the testing of assemblies of polyvinyl chloride to leather using a new footwear adhesive in association with infra-red reactivation of the dry adhesive film.

As already noted, the " Polimul " emulsions are manufactured in a self-contained plant at Fort Dunlop, having an area of 15,000 square feet and an annual capacity of 1,500,000 gallons, or 8000 tons. These emulsions are used in the production of textiles, paint, flooring, paper, adhesives and leather finishes, and the range includes polyvinyl acetate emulsions, copolymers and emulsions of polyethyl, polymethyl and polybutyl acrylate. The plant includes propeller agitated water phase tanks, which can be steam heated or water cooled, and reactors in which the reaction takes place under a blanket of nitrogen. Distilled monomer is added under pressure at a carefully controlled rate and a small amount of a catalyst, which is not recovered, is used to start the reaction. In the laboratory experimental reactors were being used to develop emulsions to meet new requirements, to improve existing formulations and examine properties for comparison purposes, and to test the possibilities of different monomers. Other equipment enabled density to be measured optically and a monomer determination apparatus measured the vinyl acetate content by steam distilling monomer in the presence of an entraining agent and by bromometric titration. Electron microscope photos revealed the particle size of the emulsions and there are tests to evaluate the scrub resistance and resistance to blistering of paints.

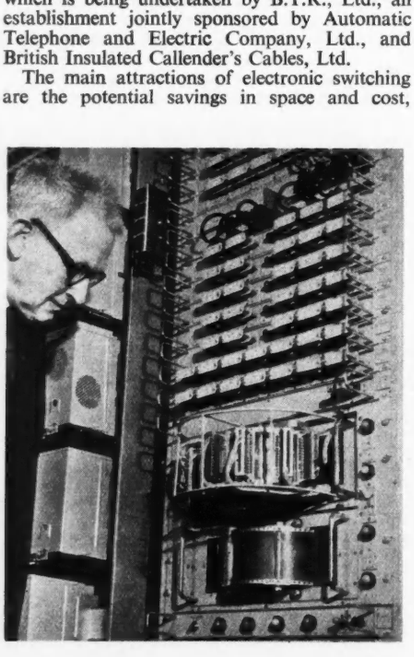
Also at Fort Dunlop, and due to be removed at an early date to the new factory, is the 1,250,000 gallons per year latex compounds plant which produces a range based upon both vulcanised and vulcanising lattices, extending from pure gum compounds to hard moulding ebonite. One of the major uses is in the manufacture of tufted carpets in which it not only binds in the pile but gives the carpet dimensional stability. Grade 2 latex compounds can be produced, at a rate of 500,000 gallons per annum, by the dispersion of whole type, red tube and drab reclaims.

Both the laboratories are served by a well-equipped pilot plant, which includes a mill for the manufacture of experimental emulsions and dispersions, mainly for paints, and another mill through which powder, wetted with water or solvent, is passed to increase the fineness of disperson. There is also a hopper for making experimental rubber solution and a general purpose mixer for the production of latex foam, using a latex solution, soap and a setting agent, in which the whipping height is related to the density. Another machine is available for the making of rubber doughs, and a set of rolls reproduces the action of ball mills on a small scale.

Electronically-Controlled Telephone Exchange

An electronically-controlled crossbar exchange has been installed in the internal telephone system at Taplow Court, Taplow, Bucks, the headquarters of British Telecommunications Research, Ltd. This exchange is designed as a practical working unit to serve 200 extensions and handle all internal communications within the headquarters organisation. At the same time the exchange forms part of the research programme into electronic telephone switching, which is being undertaken by B.T.R., Ltd., an establishment jointly sponsored by Automatic Telephone and Electric Company, Ltd., and British Insulated Callender's Cables, Ltd.

The main attractions of electronic switching are the potential savings in space and cost, particularly in the larger exchanges. Because of their high operating speeds electronic components introduced into time division systems, in conjunction with a serial storage system consisting of a magnetic drum, for example, can constitute a common controller for a very large number of circuits. With a high-speed electronic system the functions of studying the availability of routes and the state of subscribers' lines can be done very rapidly and in orderly sequence before setting-up connections. More effective use of the trunks and routes in a system can thereby be envisaged.



The internal telephone system at Taplow Court, headquarters of British Telecommunications Research, Ltd., is controlled by an electronic exchange. The magnetic drum storage device shown here provides the exchange with a " memory " whereby an engaged number is automatically recalled

The 200-line electronically-controlled exchange at the B.T.R. headquarters was built as a means of studying these principles. This exchange uses electronic means to control a crossbar (electromechanical) slave exchange which sets up the speech paths. It will be appreciated that such an electronic system could have been used to control a Strowger exchange : crossbar switches were used for preference because they can operate more quickly. In future developments of the system it may be expected that electronic equipment would be used for the speech paths as well as the controller.

A magnetic drum with its facility for storing impulses constitutes the memory of the electronic controller and provides a register for each subscriber. The drum (which can be seen in the accompanying illustration) also records the state of trunking of the exchange and decides the most suitable routes for establishing connections between subscribers. Because there is a register for every subscriber there is no need for a dial tone, for a subscriber does not need to wait for common equipment to become available. Calls can be booked to a " busy " subscriber; if the dialled number proves to be engaged the caller hangs up and then when the called number becomes free the exchange will remember the booked call and will automatically ring both subscribers and connect them.

There are two distinct parts in the Taplow exchange : an electromechanical slave to establish the speech paths and an electronic controller to govern the operations of the slave. The slave itself does no hunting. All its operations are dictated by instructions, issued through a marker unit, from the controller. Every subscriber's line is scanned sequentially in synchronism with the rotation of the magnetic drum and the condition of each line (loop or open circuit) is recorded in the subscriber's individual register. Each line is sampled sixty times per second—a frequency which is high enough to ensure that no dialled digits will be missed in the sampling process. Routes through the exchange are sampled at strategic points and the relevant information is stored on the drum.

This information is assessed by the controller and, when a subscriber has dialled the necessary number of digits, the controller sends appropriate instructions to the slave. When these instructions have been obeyed a " go ahead " signal is sent from the slave to the controller to indicate that the slave is ready to accept further orders. Details of how these operations are carried out and of the various electronic relays, inverters, cathode followers and reading and writing amplifiers for the magnetic drum are given elsewhere.[1, 2]

REFERENCES

[1] Clark, T. H., " An Electronically-Controlled Crossbar Exchange," *A.T.E. Journal*, 13, 28, 1957.

[2] Beaufoy, R., " A Set of Electronic Circuit Elements for Use with Symbolic Design Techniques," *A.T.E. Journal*, 13, 42, 1957.

ALPHABETICAL INDEX OF RESTRICTIVE TRADING AGREEMENTS.—The Registrar of Restrictive Trading Agreements states that the *Board of Trade Journal* issue of August 16 contains an alphabetical index of the commodities about which there are agreements on the public register. The index is published as it stood at July 30, 1957, and the *Journal* will issue quarterly a note of additions and amendments to it. The indexes to the register, one alphabetical as published in the *Journal* and one in which the commodities are grouped by classes, may be inspected at the office of the Registrar of Restrictive Trading Agreements Chancery House, Chancery Lane, London, W.C.2, and 9, Wemyss Place, Edinburgh, 3, or at Chichester House, 64, Chichester Street, Belfast

Fire at the Jaguar Factory, Coventry*

By L. A. ASHTON† AND G. LANGDON THOMAS‡

A VISIT was made on February 14, 1957, to the scene of the fire that had occurred at the Jaguar car factory on February 12. The object of the visit was to study the influence of the fire on the building and its contents and, therefore, the work of the Fire Service is not considered in detail.

The Factory and its Contents

The building consisted of a large, single-storey steel-framed structure, which provided the production area of the Jaguar factory (Fig. 1). The saw-tooth (north light) roof trusses, of 30ft span, were supported on steel stanchions. None of the internal steelwork was protected against fire. The roof covering was of corrugated steel sheeting protected against corrosion by a factory-applied bitumen and asbestos coating on both sides. Below this roof covering was a lining of fibre insulating board supported in metal tees, which in some bays were fixed below the purlins and in the remainder above the purlins. In portions of the roof there was thus an unstopped air gap between the roof covering and the lining. The north lights in the bays were wired glass in patent glazing. Roof ventilators had been installed about 70ft apart along the ridge of each bay. External walls were of 9in brickwork. At the mid-point of the length of the building was the main entrance, termed the "link road," which was bounded by block walls built up to the underside of the roof lining, but these walls were not continuous across the building and therefore did not form a complete separation between the assembly lines and the machine shop.

The north end of the building, which contained stores on two levels for finished components and tyres, was separated from the assembly area by wire mesh and sheet steel partitions. Adjoining the tyre stores was a saw mill similarly screened, and along the same external wall, near the centre of the building, was the paint-spraying shop, which was separated from the rest of the production area by partitioning of hardboard with glazing of plain glass.

Description of the Fire

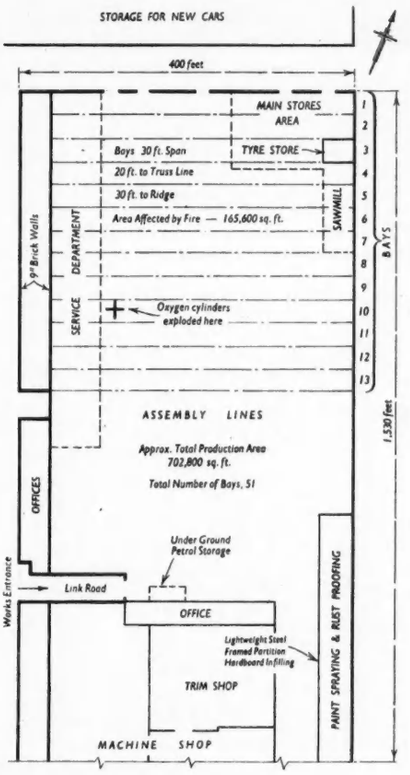
The following description of the course of the fire is based on information supplied by the Fire Services.

The fire started at the north end of the building, either in the tyre stores or saw mill, at about 5.45 p.m., shortly after work had finished for the day. It was observed in its early stages but, gaining a hold in the tyre store, it grew with such rapidity that the Works Fire Brigade was unable to control it. Flames soon reached the combustible roof lining and within a few minutes had spread along the whole length of the bay involved. Dense smoke and hot gases from the burning contents mushroomed out from bay to bay and were augmented by the products of combustion from the roof covering and lining. The absence of any vents in the roof specifically designed to vent the fire confined the smoke and hot gases almost entirely within the building. Fire spread to the contents of the building from the roof, assisted by burning material falling on to combustible material, such as fabrics, tyres and flammable liquids, in the assembly lines. It was stated that the fire in the roof was always some distance in advance of the fire on the floor.

The Coventry Fire Brigade arrived about five minutes after receiving the call and was able to enter the building by the link road. In conjunction with the Works Fire Brigade, it could still do little to halt the spread of the fire because of darkness and heavy smoke, until the explosion of an oxygen cylinder shattered a considerable area of roof glazing in the ninth and tenth bays, thus venting the fire. The relief to the firemen was immediate, and from striving merely to check the advance of the fire, they could proceed to extinguish it. Water supplies were ample and the fire was under control in a little over three hours from the time the brigade arrived. The fire was checked in its progress at the thirteenth bay from the north end of the building and twelve bays suffered damage in varying degrees.

Effect of the Fire on the Building

Apart from the place where the explosion occurred, collapse of the roof was confined to the area where high concentrations of combustible materials were present. Stanchions in this area, which had combustible material stacked close to them, had suffered severe distortion. The bitumen coating of the roof sheeting had completely burnt away in most of these bays, but in places the mineral fibre base of the coating was still adhering to the underside of the sheets. Near the limits of the fire spread, where the lining had not completely disintegrated, the bitumen coating above the lining appeared to be still adhering to the metal. Where the fire was most intense, some fusing of the glass had occurred. Elsewhere sheets of glass had dropped owing to failure of the patent glazing, probably by melting of the lead casings of the bars, but large areas of glazing were still intact.



Roof construction:
North light roof trusses. R.P.M. sheeting wire glass insulation board under drawing on metal tees.

Layout of part of factory area of the Jaguar car factory at Coventry

Discussion

As usual with large fires, the rapid and extensive spread of this fire is not attributable to one cause alone. There were several factors, none of which might have been decisive by itself, but which, in conjunction with other favourable circumstances, proved capable of producing a major fire. Given a source of ignition at the right time, a complete burn-out of the building was possible.

Precautions that should be taken to prevent a small fire becoming a large one are well known. It will be seen from the following list that the factory was deficient in many features regarded as important for fire-protection, but reasonable fire safety could be attained without taking all the precautions described.

(1) There was no sprinkler system.

(2) There were excessively large undivided areas and, in particular, no structural separation of the high hazard compartments from the remainder. Freedom from division walls subdividing the main factory was considered a production requirement of the factory, but this need not preclude the complete enclosure of the areas of high fire hazard by fire-resisting partitions. The chance of a major fire starting in the production area was probably small.

(3) The structural steelwork was unprotected. Extensive collapse of the roof of a large, single-storey building, by hampering fire-fighting operations, may lead to the building becoming a total loss. Protection of internal steelwork against fire is not a by-law requirement for single-storey buildings but may sometimes be worthwhile where the concentration of combustible material is heavy. In most factories of this type the design renders complete protection difficult and costly.

(4) The roof lining was combustible and had surfaces of rapid flame spread. It could also produce large quantities of smoke.

(5) The roof covering had a combustible coating, which could become molten when heated and fall as flaming drops, besides adding to the volume of smoke.

(6) There was an unstopped cavity between the lining and the roof covering in the bays first involved.

It has not been established that the spread of fire in the cavity was the primary cause of the rapid development of the fire. It is possible that the initial spread was on the under surface of the fibre insulating board, which burnt and broke up, the burning fragments falling on to flammable materials below. The bitumen coating of the roof covering would then be affected and would drop, adding fuel to the fire on the floor.

(7) There was no provision in the roof for venting the products of a fire. The normal roof ventilators were inadequate to deal with the large volumes of smoke and hot gases generated in the fire and so to prevent their spreading out under the roof. If it is essential to have large areas of unrestricted floor space in a building, the basic principle of compartmenting by fire walls can be replaced to some extent by making provision for the escape of products of combustion and by restricting their lateral spread by means of fire curtains in the roof space. Vents of suitable size, properly spaced, should be designed to open by means of fusible links. When combined with fire curtains in the form of screens of non-combustible sheeting, the vents provide a flue system to assist in clearing the products of combustion from a fire starting in any part of a building.

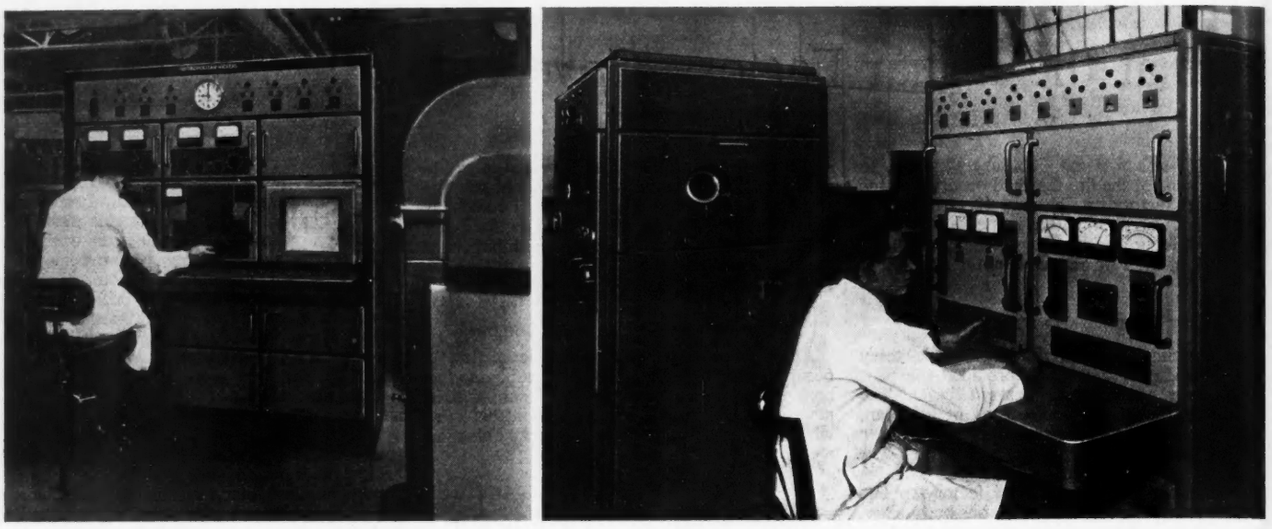
Conclusions

The fire at the Jaguar car factory illustrates the need for a wider appreciation and application of the basic principles of fire protection. There was no separation of the areas of high fire hazard (stores and saw mill) from the main production areas or assembly lines. The roof sheeting was coated with combustible material, the internal lining was fibre insulating board having surfaces of rapid flame spread, and the entire building was without any fire-resisting subdivisions. Such a layout allowed the fire to spread rapidly along the combustible roof lining, leaving large parts of the structure to a great extent undamaged but destroying valuable products on the floor below. The combustible coating on the roof sheeting also contributed to the fire, but it is not possible to distinguish between the parts played by the two materials. There have been serious fires in buildings with a roof of protected metal sheeting and no internal lining, as well as in buildings with a non-combustible roof covering and a fibre insulating board lining. Where both covering and lining are combustible, the fire can be expected to be more severe.

* Communication from Department of Scientific and Industrial Research and Fire Offices' Committee, Joint Fire Research Organisation.

† Joint Fire Research Organisation.

‡ Building Research Station.



(Left) Metropolitan-Vickers mass spectrometer type MS5 showing control unit and part of tube unit. (Right) Mass spectrometer type MS7 installed in the British Thomson-Houston research laboratories, Rugby

Mass Spectrometers for the Analysis of Inorganic Solids

UNTIL recently the main uses of the mass spectrometer have been in the isotopic assay of gases and liquids and the chemical analysis of volatile inorganic and organic compounds. While such applications remain important, an interesting development in recent years has been in the analysis of inorganic solids. Two special kinds of mass spectrometer have been designed by Metropolitan-Vickers Electrical Company, Ltd., for this work—the MS5 spectrometer for the determination of isotope ratio using the surface ionisation technique, and the MS7 spectrometer for the analysis of impurities using the spark ionisation technique.

THE MS5 MASS SPECTROMETER

The basic problem in solid analysis is to produce positive ions that are truly representative of the sample composition. A number of methods have been tried, one of the more successful being the technique of surface ionisation. There are several slightly different versions of this method, but in its simplest terms, the solid sample, in the form of a salt such as the nitrate or sulphate, is painted directly on to the surface of a tungsten filament. When the filament is heated, positive ions are emitted directly from the surface and are identified and measured, using conventional mass spectrometric techniques. The surface ionisation technique is not particularly suitable for the general analysis of solids, because different elements have widely different sensitivities, but it is ideal for the measurement of isotope ratios of solids. The MS5 mass spectrometer has been specially designed for use on this kind of problem.

The MS5 is a 12in radius, 90 deg. sector, single-focusing mass spectrometer for use with either the single or triple filament surface ionisation technique. Two particular characteristics of the instrument are : (i) a sliding-bar vacuum lock system, which enables the sample to be introduced into the instrument in less than a minute, and (ii) an ion collector system, which provides for the simultaneous availability of a normal collector (noise level approximately 3×10^{-18}A) and an electron multiplier (equivalent noise level less than 10^{-18}A). A resolving power of at least 300 can be obtained.

Nearly 75 per cent of all the elements, including most metallic elements, respond to the surface ionisation technique. The normal size of sample is a few microgrammes, but with certain elements 10^{-11} grammes will enable approximate determinations of isotope ratio to be carried out. The time required for an analysis varies from ten minutes to one hour, depending on the element and the sample size available.

THE MS7 MASS SPECTROMETER

A method of ionisation of solids employing the vacuum spark is approximately equally sensitive for all the elements. However, the use of this technique requires a double focusing instrument because of the large energy spread in the ion beam produced.

The MS7 mass spectrometer is designed for the general analysis of solids by the spark ionisation technique. It is a double focusing instrument of the Mattauch type, in which positive ions, representative of the sample composition, are produced when a high-voltage spark occurs between two electrodes formed of the sample material and placed close together in vacuum. After passing first through an electrostatic analyser and then through a magnetic analyser, the ions come to focus according to their mass as a series of lines on a photographic plate.

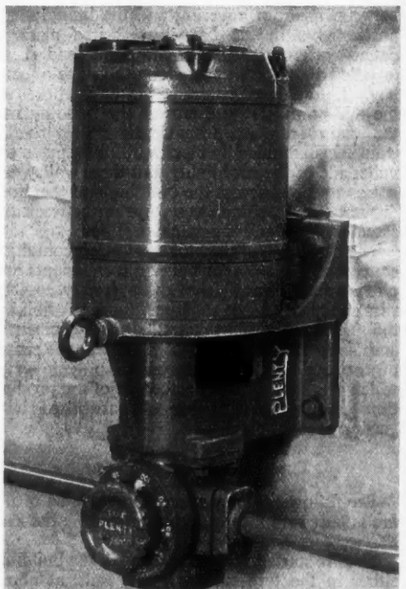
One of the more promising applications of the instrument is to the analysis of impurities in solids. For this work the photographic plate is used as an integrating device and a series of exposures of gradually increasing length are taken (a rack mechanism allows up to ten exposures to be recorded on the same plate and the exposure is accurately determined by the total integrated charge falling on the monitor collector). The concentration of the impurity is estimated from the intensity of the lines on the longer exposures and with this technique concentrations down to the level of 0·1 p.p.m. can be estimated.

The method is particularly useful for giving a general picture of the impurities in a solid. The whole mass range from 7 to 240, covering all elements, can be recorded in a single exposure of the photographic plate. Compared with emission spectroscopy, the spectra are simpler and the elements easier to identify. Moreover, qualitative and semi-qualitative analyses can be carried out without extensive calibration.

Variable-Delivery Fuel Pumps

A VARIABLE-DELIVERY fuel-oil pump recently introduced can be mounted, without bedplates, in either a vertical or a horizontal position. Made by Plenty and Son, Ltd., Eagle Iron Works, Newbury, Berks, it is a positive displacement rotary pump of the sliding vane variety, working on the principle employed by the maker since 1935. The output can be regulated by turning the control wheel (see illustration), and it is claimed that each pump will operate down to about 10 per cent of full capacity, though this depends on the medium being pumped. The percentage of full output can be set and locked, if desired, or it can be continuously adjusted to suit variable conditions. Full reverse flow can be obtained, and it is stated that this cannot be brought about inadvertently. An adjustable valve with built-in by-pass can be fitted to regulate the pressure. The provision of delivery control and pressure regulation is thought to permit setting for best economy in power input.

Nominal capacities from 200 to 1100 gallons per hour are available, and the pumps are said



This variable-delivery fuel oil-pump can be mounted in either a vertical or horizontal position. The control wheel and the graduated indicator can be seen in the illustration

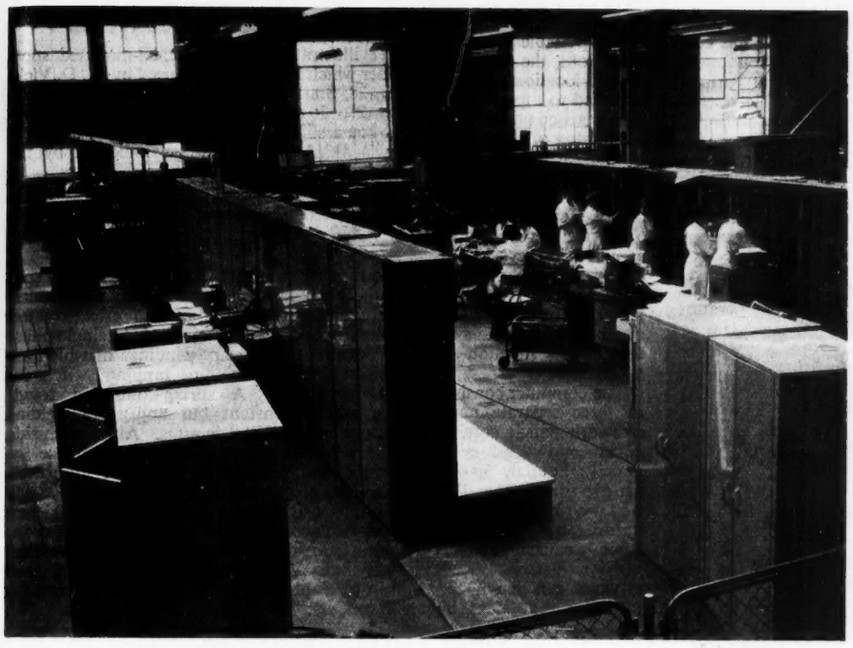
to be suitable for all grades of fuel, for pressures up to 200 lb per square inch, and for temperatures up to 250 deg. Fah. Bare pumps can be supplied, or flange-mounted units as illustrated. Pump and motor are claimed to be readily replaceable in the event of trouble.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

ELECTRIC LIFTS : GENERAL REQUIREMENTS

No. 2655 : Part I : 1957. Price 7s. 6d. This standard provides detailed recommendations for the construction and safety of passenger, goods and service lifts. Dimensions for lift wells were recommended in Part 3 of this same standard, published two years ago. Part 2, to be published later, will be concerned with the special requirements applying to the most commonly used type of lift motor. The early publication of Part 1 was called for by lift manufacturers and users, and in order to meet this demand the standard has been issued in the form in which it was circulated to industry for comment. It is expected that a revised version will be published in the not-too-distant future to include necessary amendments.



Production line of "Mercury" electronic digital computers at the West Gorton, Manchester, factory of Ferranti, Ltd. On the left is the first computer to complete its acceptance trials. On the right is the second computer during assembly

"Mercury" Digital Computer

PARTICIPANTS in the summer meeting of the Institution of Electrical Engineers in Manchester recently saw some of the stages in the manufacture of the Ferranti digital computer known as "Mercury." A number of "Mercury" computers are on order; one is due to be shipped shortly to Norway and others will be sent later this year to France and Switzerland. Seven computers are destined for service at home: one at the Atomic Energy Research Establishment, Harwell, is to be used for expediting the solution of problems on reactor design; others will go to the Universities of London, Oxford and Manchester.

The "Mercury" computer operates with a basic digit frequency of 1 Mc/s and uses the binary "floating point" system of number representation, which means that the range of the answer does not have to be anticipated. The immediate access computing store is built up of magnetic cores and consists of one accumulator with floating-point working and seven B-registers with fixed-point working. The accumulator capacity is 40 binary digits and each of the B-registers holds 10 binary digits. The storage registers have a capacity of 1024 words, each of 40 binary digits. Checking facilities are provided by a parity digit for each group of 10 binary digits, making 11 digits in all.

The main (backing) store consists of magnetic rings on drums 10in diameter and 9in long. A total capacity of 16,384 words, each of 40 binary digits, is contained on four magnetic drums. The transfer time for a single block of thirty-two words (each of 40 binary digits) is 25 milliseconds maximum, 17 milliseconds average, but the figure can be reduced by transferring several blocks in succession. The specified computing time including access time is tabulated below.

	Accumulator (40 binary digits), microseconds	B-registers (10 binary digits), microseconds
Word transfer time	120	60
Addition or subtraction	180	60
Multiplication	300	—
Division (by programme)	3½	—
Organising instructions	—	60

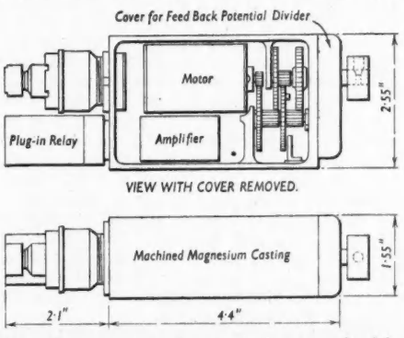
Characteristic times for various sub-routines are as follows: division, 3½ milliseconds; square root, 5½ milliseconds; logarithm, 6 milliseconds; exponential, 4 milliseconds; sine or cosine functions, 5 milliseconds. The input system consists of a five-channel single-paper tape reader having a speed up to 200 characters per second with the ability to stop on any one character.

The "Mercury" computer is made up of three bays of cabinets, which can be arranged in various ways, for example, in U or L-formation. The accompanying view of the computer assembly line at the company's West Gorton, Manchester, factory, shows: on the left, the first computer to be completed and, on the right, the second computer under construction. Arranged in a line, as shown, the computer cabinets measure 31ft 9in by 1ft 4in by 6ft 4in high, with a platform 2ft 8in wide by 10½in high along one side of the cabinets. The desk measures 6ft by 2ft 10in by 2ft 7in, and the power supply cabinet is 6ft 10in by 2ft 2in by 6ft 6in.

The power consumption depends on the auxiliary equipment in use. Normally the figure is about 40kVA, with an additional 15kVA if a refrigeration system is included. Heat dissipation is by totally-enclosed, forced-air circulation with a Freon refrigeration system. The heat is finally exhausted by an evaporative condenser or by water cooling.

Standard Range of Remote Position-Controllers

SERVO units giving shaft displacement proportional to applied voltage are offered in a standard range by Harvey Electronics, Ltd., Farnborough Road, Farnborough, Hants. Each unit consists of a box containing a small d.c. motor, amplifier and gear train as shown in our drawing. The motor is controlled by a miniature relay plugged



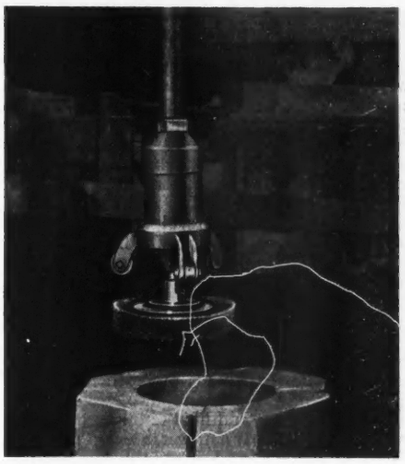
General arrangement of a standard servo unit giving shaft displacement proportional to applied voltage

into the end of the box. Output shaft displacement is measured by a wire-wound potential divider. The gears can be adjusted for backlash. Although these are on-off servos, and full power is fed to the motor on deflection of the relay, the units approximate to linearity for small errors. This is because a small oscillatory voltage is permanently supplied through the amplifier to the relay, causing a fraction of each cycle to be spent on opposite contacts. The oscillations are biased by a superposed voltage proportional to the error in shaft position, and the times spent on opposite contacts are unequal. The mean current fed through the motor is thus proportional to the error, and the approximation to linearity permits the use of the stabilising methods normal for linear systems.

As an example of the kind of performance available, the unit shown in our drawing is claimed to develop a stalled torque of 5 lb-ft and a maximum speed of 80 deg. per second at no load; for an input range of ±24V the displacement is ±28 deg. The deflection for full load (90 per cent of the stalled torque) is given as 2 per cent of full scale. Repeatability is said to be within 0·1 per cent of full-scale displacement. The maker believes that the units are suitable for remote handling equipment as used on radioactive materials, as well as for many control operations, such as those occurring in the chemical engineering industry, in spinning and weaving, in the manufacture of paper, and in rubber processing.

Billet Mould Cleaner

A SIMPLE piece of equipment has been introduced by Flexible Drives (Gilmans), Ltd., 195, High Street, Smethwick, Staffs, to provide a quick and easy means of cleaning billet moulds in situ. It consists essentially of an air motor driving a wire brush and mounted on the end of a tubular handle of the requisite length to insert the assembly the full depth of a mould. Particles of dust and scale brushed off the mould are carried



Air-motor-driven brush head of billet mould cleaner

up the handle by the flow of exhaust air from the motor.

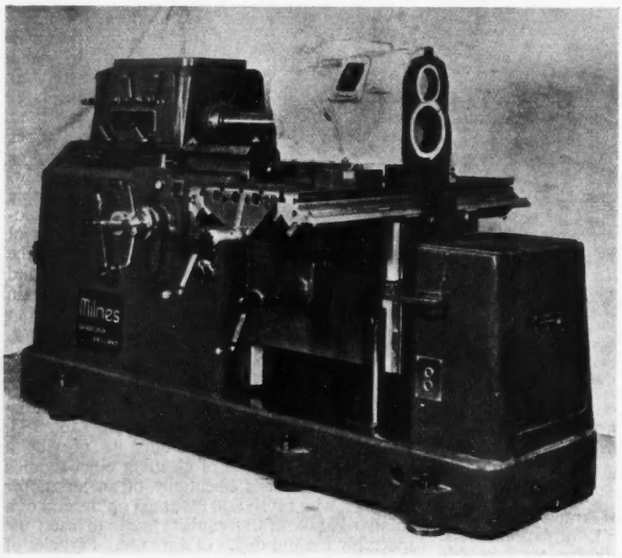
As can be seen in the illustration the brush and its drive are centralised in a billet mould by four rollers on brackets round the head. The equipment is suspended from a pulley above the mould, and counterbalanced to reduce operator fatigue. It is stated to clean a mould effectively in one pass, and is made in a number of capacities with different cleaning heads to suit particular applications.

FOAM EQUIPMENT.—The Pyrene Company, Ltd., has introduced a new portable foam branch pipe for the application of foam in large quantities. This equipment has an operating pressure of 60 lb per square inch, at which pressure it passes 100 gallons of foam solution a minute. It has a foam expansion ratio of 10 to 1, which under favourable conditions can be increased to 13 to 1. With a water pressure of 100 lb per square inch the branch pipe can deliver 1500 gallons of foam a minute. Another new piece of foam fire-fighting equipment is a light tower made of aluminium alloy which is designed for rapid automatic elevation to enable foam to be applied to such points as tank tops from a height of 70ft.

Heavy-Duty Fine Boring Machine

THE sliding-head, heavy-duty, fine boring machine made by Henry Milnes, Ltd., Rosse Street, Bradford, incorporates means of co-ordinate work setting. Its boring head has a traverse of 19½in and the worktable, which has a working surface 48in long by 19½in wide, has a vertical traverse of 15in and a cross traverse of 30in.

The machine seen in the illustration below is of particularly rigid design. The boring head, which slides on inverted double-vee ways, is fitted with a milling machine design spindle having a No. 50 International internal taper and a standard outside flange. This spindle runs on two 6in diameter precision Timken bearings and is driven by a 5 h.p. motor through gears giving twelve speeds from 40 to 750 r.p.m. Four power feeds available are from 0·0025in to 0·020in per spindle revolution and a rapid power traverse is also provided. A slipping clutch in the drive prevents damage in the event of over run, and the handwheel for manual traversing of the head is fitted with a large indexing collar reading to 0·001in.



Sliding head, heavy-duty boring machine. The sliding head of this machine has a traverse of 19½in and four speeds of from 0·0025in to 0·020in per revolution. Twelve spindle speeds from 40 to 750 r.p.m. are available

The worktable has a hand-operated traverse of 30in on the knee and when set is locked by a clamp. A power drive is provided for vertical movements of the table and knee assembly over its 15in movement and final settings are effected by a low-geared hand traverse lever. The knee elevating motor is controlled from two points—one on the main panel on the head and the other on the outer support column.

The standard measuring attachments used for both the longitudinal and vertical movements of the machine consist of steel scales and verniers, and length measuring rod equipment is also provided. If required precision scales with Hilgor and Watts magnified optical verniers can be supplied on the machine. A 20in square precision indexing table, also supplied, enables holes to be bored at right angles or long holes to be bored in line starting from each end.

The manufacturers have placed the selling agency for these machines with the Rockwell Machine Tool Company, Ltd., Welsh Harp, Edgware Road, London, N.W.2.

Analogue Computer for Cable Problems

AN analogue computer specially designed for application to heat-transfer problems in electrical cables has been introduced by Addison Electric Company, Ltd., 10/12, Bosworth Road, London, W.10. It is based on a design by J. H. Neher* in association with Lynmer Engineers Inc. With this computer it is possible to determine, without lengthy calculations, the temperature rise at various times and locations in and near a cable when it is subjected to a prescribed load cycle. Its uses can be summarised under three main headings. (1) Determination of short-time emergency ratings and of the percentage of the ultimate temperature rise reached after a specified time, with constant loads for various cable systems. (2) Determination of effects of load and maximum temperature rise resulting from a specified loss cycle. (3) Examination of oil flow problems and study of temperature rise at various points in cable systems, as a function of time.

The computer consists of three separate units (network panel, control panel and loss cycle panel) housed in a single cabinet. The network panel is made up of eight basic capacitor and resistor elements, each of which can be adjusted in 1 per cent steps by tap switches, and a ninth composite earth element. These elements simulate, respectively, thermal constants of the conductor insulation, sheath, oil or gas space, pipe (if any), and the surrounding earth.

On this panel there is an input selector switch whereby the stabilised input current can be injected at any point in the network. Normally this input current is fed to the conductor, but, by changing the input point, studies can be made of the effect of dielectric losses or of the heating of the sheath when it is used as the return path in a cable. The input current can be kept constant or it can be varied in accordance with a given loss cycle for the cable under study, as explained more fully below.

The control panel consists of a valve voltmeter with its associated control circuits. The voltmeter enables the potential difference to be measured at any point in the network and at any preselected time in the loss cycle. This instrument is calibrated from 0 to 100 per cent in terms of steady state temperature rise across the network. Provision is made for an external strip-chart recorder to be connected to the panel.

The loss cycle panel consists of twenty-four preset loss potentiometers, which are used to set up, in steps, any required loss cycle. A twenty-four step solenoid-operated selector switch allows the input current to the network to be controlled by any one of the twenty-four potentiometers. For studies of transient phenomena this selector switch is advanced cyclically. The resulting temperature rise is read at the voltmeter; where the variation is too rapid for visual observation, an electronic timer can be used to clamp the voltmeter at a preselected time.

The equipment is suitable for a 200V–250V supply at 40–60 c/s and the consumption is 180W. The cabinet measures 48in by 22in by 15in and weighs 66 lb.

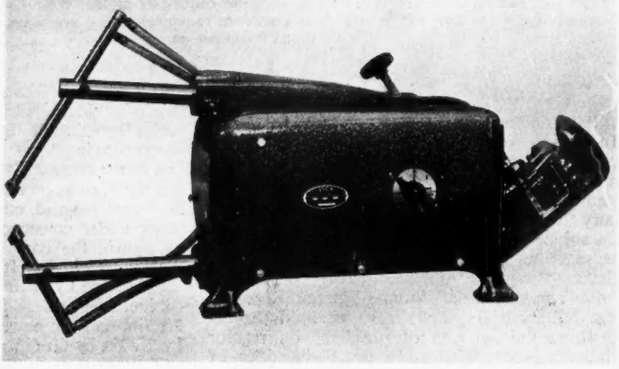
* J. H. Neher, "The Determination of Transients in Cable Systems," *Proc. A.I.E.E.*, Vol. 70, 1951.

8kVA Bench Spot-Welder

WE illustrate an 8kVA bench-mounted spot-welder which has been introduced by W. D. Vick, Ltd., 28, Station Road, Acocks Green, Birmingham, 27. It measures 31in by 10in by 16in high and has a slightly larger capacity than the company's 4kVA spot-welder, as indicated by the following data:

Rating	Maximum capacity steel sheets (s.w.g.)	Throat dept. (in)
4kVA	2×16	10
8kVA	2×12	12

Both versions of this spot-welder are of substantially similar construction and appearance. The equipment consists of a fabricated steel frame supporting an air-cooled, single-phase transformer, the primary windings of which are connected to a four-point tapping switch for heat regulation. A spring-controlled toggle lever exerts constant but adjustable welding pressure on the electrode arms. Aluminium side castings with a grey hammer finish enclose the machine and reinforce the frame. Adjustable cylindrical electrode arms provide upright and inclined positions for the electrode holders, giving free access to the work. Hollow electrode holders provide water cooling up to the electrode tips. Visual indication of water flow is given by a plastics connecting tube between the two holders.



8kVA bench-mounted spot-welder with a capacity up to 2×12 s.w.g. steel sheets

A hinged panel at the back of the machine, as can be seen, carries an electronic timing unit, which is provided with a graduated control knob whereby the welding time can be adjusted between 0·1 and 3 seconds. Regulation of the welding pressure is done by a control knob on top of the machine. A heat switch with four engraved positions is fitted on the side of the machine and connected to the transformer primary winding.

The machine is operated by a pedal, which actuates the top arm through a spring-controlled toggle mechanism; the top electrode closes on the work and further depression of the pedal closes a micro-switch at the back of the machine to operate an electronic timer which closes the main contactor and then opens automatically after completion of the timing period.

A water cooling system complete with circulating pump and a water-cooled bottom arm are available as extra items.

REINFORCED POLYTHENE SHEET.—The Plastics Division of the Telegraph Construction and Maintenance Company, Ltd. (Telcon), has developed its extrusion coating technique to produce a thin polythene sheet reinforced internally with an open mesh of fibre glass, "Terylene" or suitable synthetic or natural textile. The material is named "Telcomesh" and possesses impermeability and chemical resistance as well as mechanical strength, and is useful for lining tanks, for protective clothing and for many applications in the building, food and confectionery industries. The breaking strain of the material is given as 45 lb per inch for 0·017in thickness, and 28 lb per inch for 0·009in thickness, and the bursting strength as 140 lb and 125 lb per square inch for the respective thicknesses given.

Diesel Electric Locomotives for Jamaica

AN order for ten 750 h.p. diesel electric locomotives for the Jamaican Government Railway has been completed by the English Electric Company, Ltd. One of these locomotives can be seen from the driving cab end in the photograph we reproduce on this page and its leading particulars are given in the table below.

Gauge	4ft 8½in.
Length over buffer beams	41ft 11½in.
Height above rail level	13ft 5½in.
Maximum width	9ft 6in.
Distance between bogie centres	22ft 6in.
Bogie wheelbase	8ft 6in.
Minimum radius of curve negotiable	240ft.
Weight in working order	63·5 tons.
Maximum axle load	16 tons.
Maximum tractive effort (25 per cent adhesion)	35,500 lb.
Continuous rated tractive effort	24,900 lb.
Maximum safe speed	60 m.p.h.

The locomotive is powered by a "6.SRKT" four-stroke, pressure-charged engine having a continuous traction rating of 750 b.h.p. at 850 r.p.m., and directly coupled to the main generator. This generator is a six-pole machine with a continuous rating of 500kW, 500V, 1000A at 850 r.p.m. The four traction motors each have a one-hour rating of 228 h.p., 300V, 650A.

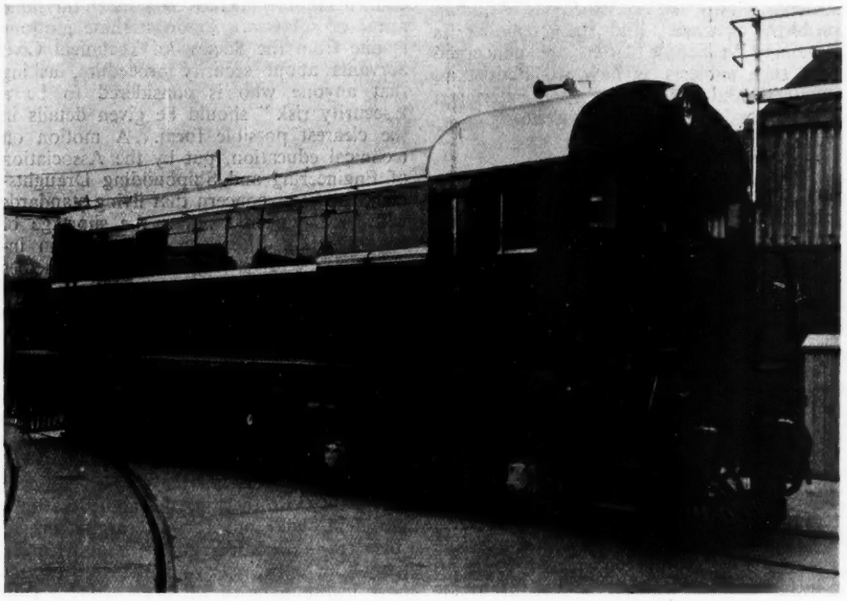
In the driving cab there are two driving positions in diagonally opposite corners and, in addition to the brake controller, the driver has a compact power controller with two handles. One handle sets the reversers for the required direction of travel and the other controls the power developed by the engine. The main control handle operates a small number of contacts which establish the basic electrical circuits, but variation in power is effected pneumatically. Movement of the control handle causes the air pressure in a control pipe to build up to an amount corresponding to the movement of the handle. This air pressure actuates a spring loaded piston on the engine governor, so causing the engine speed to increase. Electrical contacts on the governor actuate a motor-operated torque regulator which varies the generator field to maintain the load imposed on the engine at the correct figure corresponding to the engine speed. The full power corresponding to any position of the master controller handle is available over the range of locomotive speed, the torque regulator initiating field weakening of the traction motors as required. The maker points out that with this system the engine speed is continuously variable from idling to full rated speed; the driver sets the power output to suit traffic requirements and the loading is automatically adjusted to this value irrespective of locomotive speed; and the engine never runs at a higher speed than the minimum needed to produce the power demanded. The design is such that consumption and maintenance are substantially less than with a stepped speed system, and the equipment and train lines required are less than with other systems.

The narrow bonnet superstructure, with a full width driving cab at one end, provides good visibility in either direction of travel. The bonnet is divided into three compartments. The first compartment houses the air compressor, air brake equipment and one traction motor blower; the second houses the two side radiator panels, with a roof mounted radiator fan; and the third houses the power unit and a second traction motor blower. The control equipment is mounted in a dust-proof cubicle which forms the front wall of the driving cab.

The underframe is fabricated from two main I-section longitudinals and two channel section sole bars, reinforced and cross braced where necessary, with drag boxes at each end to accommodate the centre couplers.

The bogie frames are of riveted and welded construction with box-section fabricated side members riveted to fabricated transom and headstocks. The superstructure is carried on a large diameter centre bearing which also transmits the thrust from the bogie. Each bogie has a cast steel bolster resting on laminated elliptic springs carried on a spring plank which is connected to the bogie frame by inclining swing links. The bogie frame is supported on four groups of coil springs which in turn are carried on forged steel equalising beams. Roller bearing axleboxes are fitted with renewable manganese steel liners, as are the axle box guides and the bolster thrust rubbing faces. Air operated brakes are fitted with individual brake cylinders operating clasp brakes on each wheel.

The climatic conditions in which the locomotives are designed to operate make necessary adequate protection against the effects of dust, torrential rain and tropical humidity. Air for the engine is drawn through oil-wetted metal filters in the locomotive sides and ducted directly to the pressure charger intake. Air for the traction motors is drawn through similar filters by the traction motor blowers and ducted to the traction motors. Engine-room air drawn through large filters at the generator end is extracted at the front end by the radiator fan, and all the air filter elements are protected by louvres to prevent ingress of tropical rain.

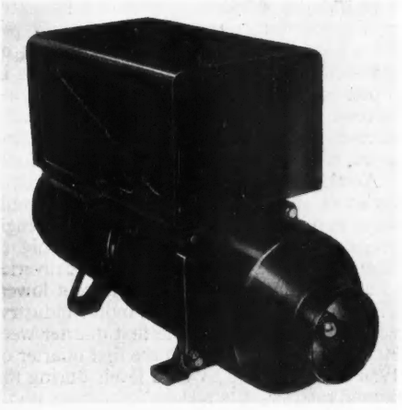


750 h.p. diesel-electric locomotive for the Jamaican Government Railway. With a continuous-rated tractive effort of 24,900 lb, these 63-ton locomotives have a maximum safe speed of 60 m.p.h.

Inverters for B.E.A. "Vanguard" Aircraft

A NUMBER of inverters are being made by the aircraft electrical division of The Plessey Company, Ltd., Ilford, Essex, for use in the "Vanguard" civil aircraft ordered by British European Airways from Vickers-Armstrongs (Aircraft), Ltd. The inverters, which are of a new design, have an unusually high power-to-weight ratio. Each equipment, one of which is illustrated here, weighs less than 60 lb and is 19½in long by 7 1/16in wide and 11⅞in high, including the control panel mounted integrally with the inverter. From a d.c. input supply, which may vary between 25V and 29V, the inverter provides a three-phase output of 200V, 400 c/s, 3kVA at any power factor between 0·8 lag and 0·95 lead for use in instruments, radar and allied equipment.

The inverter is self-cooled up to 10,000ft, and is capable of operating on full load in ambient temperatures between −30 deg. to +45 deg. Cent. Under all these conditions the output voltage is held to a tolerance of ±2½ per cent of 200V and the frequency to ±3 per cent of 400 c/s. These close tolerances are maintained by means of two control circuits, the voltage control being by means of a carbon pile regulator, with a compounding transformer, and the frequency control by means of a centrifugally operated carbon pile governor of novel design. Both circuits are integrally mounted, and the control panel also contains the starting gear and radio interference suppression components.



An output of 3kVA can be obtained from this Plessey inverter which weighs less than 60 lb and is designed for use in the Vickers "Vanguard" civil aircraft

The d.c. motor consists of a shunt-wound machine incorporating a compensating winding and a speed control winding, the latter being fed from the control panel. In addition, a swamp resistance is in series with the shunt winding to compensate for the large variation in ambient temperature in which the inverter has to operate. The cooling fan of the machine is designed to draw the cooling air through 20ft of straight ducting; a flame trap is fitted at the air outlet, to ensure safe operation in an atmosphere which may become contaminated with explosive vapours. The inverter is designed to operate without maintenance for times of 1000 hours. It has been approved by Trans Canada Air Lines for their "Vanguard" aircraft, which are due to go into service in 1959. It is to be shown for the first time at this year's S.B.A.C. exhibition at Farnborough.

BUSINESS EFFICIENCY EXHIBITION AT CARDIFF.—A four-day exhibition, organised by the Office Appliance and Business Equipment Trades Association, will be held at the Sophia Gardens Pavilion, Cardiff, from September 17 next. Fifty-four firms have already booked space, and the exhibition will cover over 15,000 square feet and will be one of the largest regional displays of its kind. In the four years since this exhibition was last held in Cardiff, output of office machinery has increased from £29,400,000 to £45,000,000 a year and exports of office machinery and auxiliary equipment such as office furniture have grown from £15,000,000 to nearly £25,500,000 a year.

Industrial and Labour Notes

Steel and Iron Production

The monthly statement on steel and pig iron production for July has been issued by the Iron and Steel Board. It shows that steel production in July was at the rate of 362,500 tons a week, compared with 326,400 tons a week in July, 1956. This is the highest weekly rate for July so far reached. For the first seven months of the year production averaged a weekly rate of 417,900 tons and was 6·5 per cent above production in the corresponding period of last year. Pig iron production at the weekly rate of 263,400 tons was also a record for the month of July. Production for the first seven months of the year was 7·7 per cent above that in the corresponding period of last year.

Deliveries of finished steel products during the first half of the year were up by 2·7 per cent on deliveries in the first half of last year. This increase is less than that in crude steel production during the same period (5·1 per cent) because of the rather lower import of semi-finished steel and because of changes in producers' stocks. There was a substantial increase in deliveries of heavy products, ferro-concrete bars and tinplate, and a decline in deliveries of sheet, strip and light sections.

Among consuming industries direct deliveries of steel to shipbuilding, mining, railways and building and constructional engineering were in total nearly 7 per cent higher than in the first half of 1956, while deliveries to all other industries were 6 per cent lower. The latter group includes the motor industry, where deliveries during the first quarter were 30 per cent below those in the first quarter of 1956 but recovered to 1956 levels during the second quarter.

Proposed Tube Making Plant

A preliminary arrangement has been made between Stewarts and Lloyds, Ltd., and John Summers and Sons, Ltd., whereby hot-rolled steel strip will be supplied by John Summers and Sons, Ltd., to an electric resistance welded tube plant to be installed adjacent to the firm's works at Shotton by Stewarts and Lloyds, Ltd.

The tubes to be produced will be in the size range of 6⅝in to 16in outside diameter and are intended in large part for export to the oil industry.

To make the necessary tonnage of hot-rolled strip available to Stewarts and Lloyds, the output of the Shotton works will be increased, but this will not affect the supply to industry of the increased tonnage of cold reduced sheets envisaged in John Summers's current development programme. The new tube plant is expected to go into production early in 1960, and the strip requirements are likely to be approximately 100,000 tons per annum initially, rising after some years to 200,000 tons per annum. It is stated that approval of the scheme has been given in principle by the Iron and Steel Board and the British Iron and Steel Federation and detailed plans are now being worked out.

Stewarts and Lloyds, Ltd., points out with this new production it will be able to supply electrically welded and seamless linepipe in all diameters up to and including 16in o.d. With the new facilities the company will be able to use a larger proportion of its seamless tube capacity for making casing, which it expects to make available in 1959. By 1960/61 it is expected that the firm's present output of tubes for the oil industry will be increased by some 80 per cent.

Industrial Welfare

A full programme of conferences, courses, and other meetings, has been arranged by the Industrial Welfare Society, 48, Bryanston Square, London, W.1, for the period from September to December of this year. In the series of courses of which details have been sent to us are included, for instance, evening study groups on subjects of practical importance to foremen and forewomen, designed mainly for the young supervisor. Other courses give instruction to managers and executives.

On September 24, the society's director will give an address in which he will expound his assessment of "Human Relations in Industry," and give some indication of the future of that topic as seen by the society.

Nine new films have been made by the society. Two are classified as "human problems at work," and the remainder as "training"; these latter are concerned with such subjects as how to conduct an interview, and of problems when entering a new job, and of health and hygiene.

Trades Union Congress

The T.U.C.'s eighty-ninth annual congress is to be held at Blackpool during the period September 2 to 6, and the general council's report to the congress has just been published. The report is a lengthy document and the subjects on which opinions are expressed by the general council range over international matters, economic policy, industrial development, education, social insurance and matters of trade union practice.

The biggest issue in economics which the general council had to face was considered to be the proposal for a European free trade area; Britain could not join a common market, the general council states, but would be unwise to stay out of a free trade area. Statements of policy on this topic stress the safeguards which are considered essential, principal amongst which is the need for specific provisions "relating to the obligation of member countries to achieve and maintain full employment."

As to the economic situation during the year at home, criticism of government policy is expressed. The main need, in the general council's view, was "to stimulate production and reinvigorate investment" and that the Government had significantly failed to do. The Suez policy also was subjected to condemnatory criticism.

Few things had disturbed the general council more, however, than the Government's attitude towards the problem of Britain's roads. The report points to the well-known situation in which accidents are heavy and congestion is widespread, and goes on to suggest that, as a matter of urgency, a Governmental committee should be set up to inquire into the matter, and to study "economic and organisational" aspects of it. Such an investigation was pressed in the report, despite the recent announcement of increased expenditure on roads.

The report also includes an expression of doubt about the scale of investment intended in nuclear power. Nuclear energy could only make a small contribution for some years, the report points out, and further development would be embarrassed by the rate of technical advance, which was so great that present nuclear power stations were likely to be out of date in five years' time.

The general council's views on technological development, and in particular development covered by the term "automation," is set out in some detail in the report. The council wishes to be associated with the British Conference on Automation and Computation which is being set up by the three senior engineering institutions.

Congress Agenda

The Trades Union Congress, when it assembles in Blackpool next month, will consider the general council's report and the matters therein to which we have just referred. The proceedings of the congress will also include the debating of motions put forward by various individual trade unions, classified generally along the same lines as the general council's report, and covering much the same range of subjects. Amongst these motions is one from the Society of Technical Civil Servants about security procedure, asking that anyone who is considered to be a "security risk" should be given details in the clearest possible form. A motion on technical education, put by the Association of Engineering and Shipbuilding Draughtsmen, expresses concern that living standards will be endangered unless the shortage of suitably trained technical personnel in industry is not overcome; various remedies are suggested. Improved co-ordination in fuel and power policy is suggested by the Association of Scientific Workers.

Annual Conference of Engineering and Shipbuilding Trade Unions

The Confederation of Shipbuilding and Engineering Unions held its annual conference last week at Hastings. One of the principal speakers at the conference was Mr. H. G. Brotherton, the confederation's president, who put forward arguments to support the confederation's claim for a forty-hour week, which was recorded on this page in our issue of July 26. He was supported in this view by Mr. W. J. Carron, president of the Amalgamated Engineering Union, who considered that the shorter week would not need to entail a loss of productivity. Holiday pay was also debated, and a proposal calling for a third week of annual holiday with pay was adopted.

Another matter of principal concern to the conference was that of public ownership. The Labour Party's policy on this matter was criticised, and several trade unionists pressed the view that further nationalisation of industry was desirable. Two industries which the conference considered especially to be in need of nationalisation were the aircraft industry and the machine tool industry. The competitive power of the machine tool industry would be improved by nationalisation, according to one speaker, and nationalisation, it was stated, "would end the muddle in the aircraft industry." The Transport and General Workers Union dissented from the nationalisation motion. Other matters discussed at the conference included a guaranteed annual wage and automation, a resolution being passed that gains from automation should be reflected in price reduction.

Alpine Road Tunnel Projects

Since the completion of the last of the great railway tunnels in the Alps in the early part of the present century, road traffic has increased to an extent which it was then impossible to foresee. Some of the early tunnel schemes which were dropped because of competing projects are being revived as road tunnels, making possible all-the-year-round road traffic across the Central Alps. In this category are the tunnels under the Mont Blanc and under the Great St. Bernard which form the subject of the present article.

SINCE the opening of the last of the great railway tunnels in the Central Alps in the first two decades of the century, the increase of motor traffic, both commercial and tourist, has led to the reconsideration of certain tunneling schemes which had been given up at the time because of competing projects. Although the Alpine roads have continuously been improved to enable them to cope with modern demands, the Alps still form a considerable obstacle on account of the long gradients which are encountered, and the extra distances which are entailed by the winding nature of the roads. What is, however, most serious is that the higher passes are obstructed by snow in most years from about November until May.

One of the most important routes is that from Western Europe into Italy. Two major tunnel projects have come to the fore in recent years, of which one, the road tunnel through the Mont Blanc, was to have been begun this year. At the beginning of August it was, however, announced that because of the French economy measures, construction would be postponed. This decision focusses attention once again on the rival project which concerns the neighbouring Great St. Bernard.

There are many factors in favour of the Mont Blanc tunnel. In spite of its height, the massif is comparatively thin, the distance from the valley of Chamonix to that of Entrèves-Courmayeur being about 12km. Geological studies indicate that no major obstacles to the work should be encountered such as were met with on the Simplon and Loetschberg. On the French side, Chamonix is readily accessible from such important centres as Geneva and Annecy, while on the Italian side is the important town of Aosta and, farther down the valley, the traffic centre of Ivrea with its road connections with Milan, Turin and Genoa.

It is of interest to consider why such a favourable situation did not lead earlier on to the construction of a railway tunnel. The reasons for this must be sought in the political conditions of the times. The Mont Cenis tunnel was commenced in 1857 on the initiative of Cavour to link Turin and Chambéry. The St. Gotthard tunnel, which was opened in 1882, was favoured by Bismarck, as it seemed a further factor tending to reduce the power of France. When the line from Le Fayet to Chamonix was built in 1891 the company chose a gauge of 1m. Eventually the decision fell in favour of the Simplon, the tunnel being completed in 1906.

The Mont Blanc Tunnel

The chief modern protagonist of the Mont Blanc tunnel was the French engineer, Arnold Monod, whose earliest project dates from 1907. On account of the outbreak of the first world war it had to be shelved, but was revived by Monod in 1928 in the form of a road tunnel. A Franco-Italian-Swiss syndicate was formed in 1935, but the Abyssinian war prevented any actual construction.

Since the end of the second world war the French Government has been in favour of the project, as against the proposed alternatives of Fréjus and the Great St. Bernard. An Italo-French agreement was signed on March 14, 1953, and the decision was ratified by the French National Assembly on January 23 of this year. Half the work was to be carried out by a French firm, the other half by an Italian firm. France was to contribute 6000 million francs, Italy 4000 million, and Switzerland 700 million. It was intended to have the tunnel in operation by 1960.

As regards the Fréjus (Mont Cenis) tunnel, conversion of the existing railway tunnel between the French frontier at Modane and the Italian town of Bardonecchia had been suggested. Between the north entrance at 1130m sea level and the Italian southern end at 1291m, there is a distance of 13,636m. The suggestion was to convert the railway tunnel for road traffic and to pierce a second, parallel tunnel for the railway. Although the plan appeared technically attractive, it was eventually considered that the site was too far from the main traffic routes, and that the neighbourhood, though easily accessible by road, was not of sufficient interest to tourists to attract the required numbers of visitors.

In Fig. 1 we show the sectional elevation of the Mont Blanc tunnel. Access from the French side is from the village of Les Pèlerins, between Chamonix and S. Gervais-les-Bains. From the main road the tunnel portal is reached in three hairpin bends. It will probably be situated at a height of 1203m above sea level, although a recent study has shown that it might be preferable to site the tunnel entrance slightly differently at 1250m. This solution would reduce the length of the tunnel from 11,900m to 11,750m, and the gradient on the French side from 3 per cent to 2·4–2·5 per cent, a fact which would be of some importance in relation to heavy goods traffic.

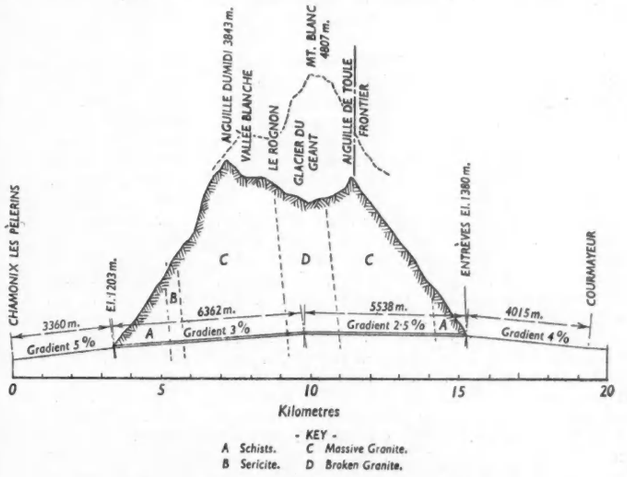


Fig. 1—Section of Mont Blanc road tunnel

The entrance as originally planned would lie between the streams La Creuse and Les Faverands, and in order to traverse the latter stream more readily and to ensure freedom from avalanches, the first section of the tunnel would be a curve of 500m radius. As compared with a completely straight tunnel, this would have the advantage that the entrance would not be visible during the greater part of the journey. The glare from a small opening of sky can be extremely irritating to drivers. The access road, it is stated, will have a gradient of 5 per cent except in the hairpin bends, where the gradient will be reduced to 3 per cent.

At the Italian end, at the hamlet of Entrèves above Courmayeur, the access road will connect over two hairpin bends with the existing road to Aosta. The gradient here will be about 4 per cent. Both access roads will be on sites protected from the wind and capable of being kept snow-free.

Geology.—On the basis of extensive geological studies,* is would appear that in the first 2·5km one would encounter crystalline schists with a high proportion of Sericite, a kind of mica. The grain of the rock here is medium to fine. After this section comes granite (protogyne) which forms the mass of the mountain. The grain here is coarser and crystals of feldspar up to 10–15cm are encountered. In the higher layers of the protogyne are found entrained sedimentary rocks transformed into hornfels, with very fine grain. Crushed zones have been entrained by tertiary slips around the fractures. On the whole, the rock is sound and normal methods of supporting the roof will, it is thought, suffice. The overburden has an average thickness of 2000m and is sufficiently great in places to cause spontaneous failures at the sides of an unlined tunnel.

Rock temperatures are not considered likely to exceed 50 deg. Cent. and may be reduced by water sweating to 45 deg. Cent. Although cold springs may be encountered, it is not considered likely that hot springs from deeper layers will be met with.

After traversing the protogyne over a length of some 7km, the tunnel pierces 2km of mesozoic schists or calcareous rock which are also considered to be entirely suitable for tunnelling. All layers of rock throughout the massif dip steeply towards the south-east, at angles from 60 deg. to 75 deg.

Traffic Conditions.—Traffic surveys indicate that the tunnel should in the first instance be laid out for a total traffic in both directions of 350 vehicles per hour. If this should prove to be insufficient later on, a second tunnel would be driven in parallel with the first,

Tunnel Section.—Fig. 2 gives two of the proposed cross-sections, one for self-supporting parts of the tunnel, the other for regions of extreme rock pressure.

There is to be a roadway of 7m width, with footpaths 0·35m wide on either side. The cross-section would be such as to give a clear height above the edges of the roadway of 4·35m, and a height of 4·80m above a 3m wide strip in the centre of the road. Every 50m, niches are to be provided and garages 20m long by 3m wide by 4·50m high are to be built every 500m, alternately, on each side of the tunnel. Most of the intrados is to be lined, partly for safety and partly in order to reduce air resistance. Underneath the roadway a ventilation and drainage gallery of 2m by 2m is to be provided.

Construction.—Construction will be over the full section using jumbos equipped with fourteen drills. For each stage, seventy to eighty holes would be drilled, each 3·30m long and 40mm in diameter. Tubs would be charged mechanically and removed by electric locomotives. With four six-hourly shifts per day, it is thought possible to achieve a daily advance of 12m.

Ventilation.—The most novel design problem is that of ventilation, as this is the first road tunnel of such length to be built.

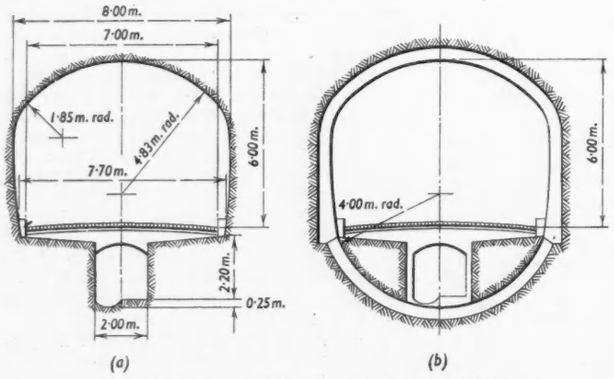
Provision must also be made for adequate ventilation during construction,. In the case of previous long Alpine tunnels, quantities of air from 3 to 25 cubic metres per second were introduced, but the amounts which actually reached the working face were only a small fraction of these figures, owing to leakages. In the present case it is intended to blow in some 20 cubic metres per second, which because of improved

* By Killian, Lugeon, Jacob, Francki, Oulianoff and Baretti.

ducting should effectively reach the face.

The main question is the removal of carbon monoxide during actual operation. It is considered that concentrations up to 250 p.p.m. could be tolerated. Several studies have been carried out with the object of determining the most suitable ventilation system.

The French syndicate, on the basis of researches by A. Monod and A. Caquot, concluded that with a traffic density of 350 vehicles per hour, a longitudinal or semi-longitudinal system of ventilation would not be adequate for a tunnel of such length. In case of fire, it is imperative that the products of combustion should be removed immediately. The syndicate, therefore, favoured a system of transverse ventilation requiring about 4820 h.p.



(*a*) In sound rock with low pressure, "Gunite" lining only.
(*b*) In zones of extreme pressure.

Fig. 2—Typical cross sections of Mont Blanc tunnel as proposed by the Italian syndicate

The Italian syndicate, on the basis of a design study by Société Rateau made in 1949, which assumed sixty vehicles per hour, at first stated a preference for the "semi-transverse" method, but eventually changed their opinion in favour of the transverse system.

In the layout suggested by them, fresh air would be blown in by means of two ducts, each 1400mm by 1250mm wide. These ducts would lie underneath the roadway on either side of a central duct 1600mm by 2000mm wide, through which the used air would be extracted. Branch air ducts would supply fresh air at road levels, while other branches would extract the exhaust air at the crown of the tunnel. The scheme would require about 1500 h.p.

Later studies based on the 1800m long Croix-Rousse road tunnel at Lyon, may be summarised as follows: a substantial natural draught may be expected because of the difference in level of the two ends of the tunnel, and the internal evolution of heat from the rock as well as from vehicle engines. This draught is, however, far below that required for the amount of traffic which is envisaged, and depends also on variable meteorological and traffic conditions. A system of forced ventilation is therefore considered essential.

The arguments against longitudinal ventilation—insufficient capacity and the danger from the high air velocity in case of fire—ruled out a solution based on assisting the natural circulation by having an injector station at the lower (French) end and several accelerating stations along the tunnel (Saccardo system).

Since traffic density did not warrant the expense of the classical transverse system,† and the semi-transverse aspiration of contaminated air was found to be inadequate, the solution to be adopted is the semi-transverse blowing-in of fresh air. With a fresh-air conduit of 3m diameter, which would be placed underneath the roadway, the power required for the fans would be 1600kW for a total of 200 vehicles per hour, and 5000kW for 300 vehicles per hour. (These figures would, of course, be lessened if the diameter of the air duct were increased.) The cost is stated to be substantially lower than for purely transverse ventilation, and not to be much greater than for the longitudinal system.

† Large suburban tunnels with transverse ventilation have capacities of up to 1500 vehicles per hour.

The Great St. Bernard Tunnel

A project which is to a large extent in competition with the previous one is that for a road tunnel under the Great St. Bernard Pass, between Italy and Switzerland. The idea for a tunnel in this region goes back to 1850, when such a tunnel under the Col de Menouve, a few kilometres to the east, was projected, and construction did, in fact, commence. The project was revived in 1873, to be followed in 1884 by the first plan for a Great St. Bernard tunnel. In 1936, the consulting firms Chauvie, of Turin, and Boucher and H. Chenaud, of Prilly (Vaud), produced their project which forms the basis of all subsequent developments.

The national and military arguments in favour of either scheme are outside the scope of the present article. The advocates of the Great St. Bernard maintain that their tunnel—which would be laid out for a maximum of 200 vehicles per hour—would require rather less than half the cost of the Mont Blanc tunnel. Moreover, such road distances as Milan–Paris or Genoa–Strasbourg are somewhat shorter by the Great St. Bernard than by the Mont Blanc tunnel route.

The Great St. Bernard tunnel (Fig. 4) would have a total length of 14·6km and extend from near Bourg St. Pierre in the north to a point above St. Rhémy in the south. Of this total length, the actual tunnel itself would be only 5880m long, the remainder consisting of covered access roads. It is considered that all of the region of the tunnel consists of crystalline rocks without marls or clayey schists, and that no difficulty is to be expected from underground water.

The northern access road would start at 1670m above sea level and have a length of 5500m, with a gradient of 4·8 per cent. Throughout its length it would be covered in by a concrete structure consisting of prefabricated elements, with either removable or fixed sides made from timber or concrete slabs. The tunnel entrance would be at 1905m above sea level, and at this point there would be a communicating passage with the existing road over the pass, and a parking space of 10,000 square metres, as well as a hydro-electric power station for supplying the ventilators, lighting and heating.

The tunnel itself runs in a south-westerly direction for half its length (2940m), with a gradient of 0·2 per cent, reaching its highest point (1911m above sea level) at the centre. At that point there is to be a vertical shaft 370m high to the surface. The tunnel continues at a more southerly angle with a slope of 2 per cent, to emerge at a level of 1826·7m into a covered access road, similar to the one in the north, which descends to the Italian entrance with a maximum gradient of 5 per cent, to meet the existing road over the pass at a point 1705m above sea level 23·35km from Aosta. A typical cross-section is shown in Fig. 3. It will be seen that there is to be a carriageway 7m wide for two-way traffic, with footpaths 0·50m wide on each side. At intervals, additional space for garaging is to be provided. The tunnel will be driven from both ends, after which the ventilation shaft is to be constructed from underneath. This part of the work, it is estimated, will take thirty months, and the whole scheme is to be completed within three years.

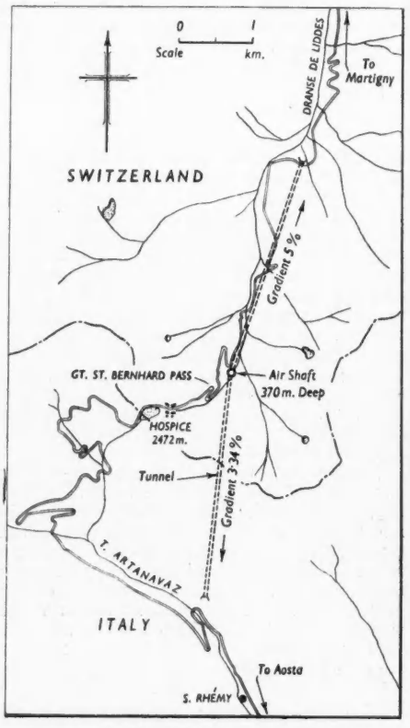


Fig. 4—The Great St. Bernard road tunnel

Ventilation.—As the tunnel is only about half as long as the Mont Blanc project, ventilation problems are also less serious. The provision of a 370m high ventilation shaft in the middle of the tunnel will, it is stated, contribute a large amount of natural circulation.

Tests in the United States and at Zürich are stated to have shown that private cars produce from 120 to 150 cubic centimetres of carbon monoxide per metre of run, and lorries up to 200 cubic centimetres. In the calculation a permissible concentration of 250 p.p.m. was assumed. The project provides for transverse ventilation, as indicated in Fig. 3, sufficient for a traffic density of up to 200 vehicles per hour.

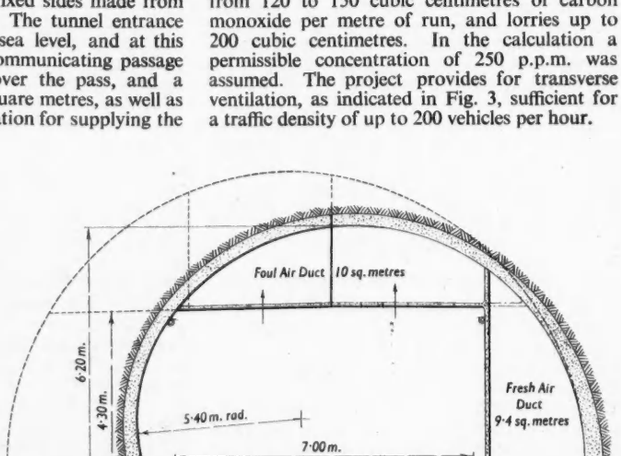
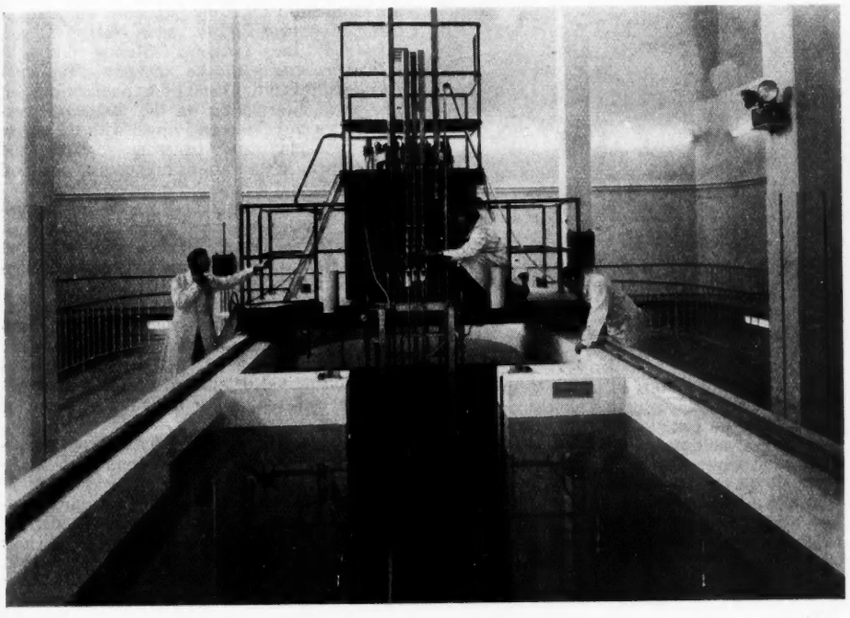


Fig. 3—Typical lined section for Great St. Bernard tunnel (total length about 1500m). The remaining 4500m will be "Gunite" lined. The walls of the air ducts will be of prefabricated reinforced concrete. The dotted section is for garaging

The Wurenlingen Research Reactor

Two years ago, on the initiative of a number of leading Swiss firms, chief among them Brown Boveri et Cie, of Baden, the Reaktor A.G. (Reacteur S.A.) was founded at Würenlingen with the object of providing experimental facilities in Switzerland for the study of atomic energy and the training of staff. At the beginning, 141 firms became associated with this undertaking, which received financial assistance from the Federation ; the number of participating firms has since increased to 157. As a first step it was decided to acquire an American reactor for testing purposes. This equipment, a " swimming pool " reactor, has recently been inaugurated.

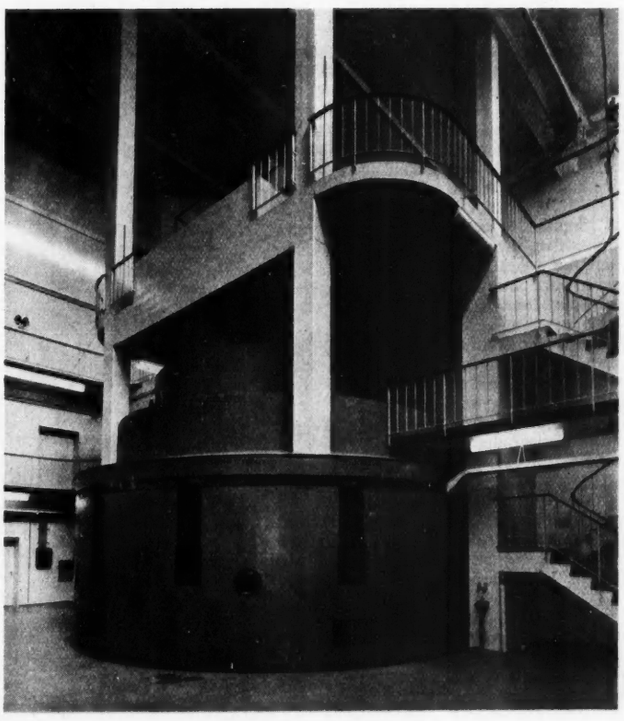


The reactor core is immersed in the 8m deep water tank, and together with the controls and safety devices is supported by the movable bridge. A watertight bulkhead can be inserted to enable one-half of the tank to be drained. This facilitates the setting up of experiments

PRELIMINARY studies of the question of the technical application of atomic energy began in Switzerland, as elsewhere on the Continent, shortly after 1945. No further practical steps were taken, however, until the foundation two years ago of an organisation for the study of technological and industrial nuclear problems. This organisation was founded by several leading Swiss firms on the initiative of Brown Boveri et Cie, Baden. It was one of the principal objectives of the new company to acquire an experimental reactor suitable for materials testing. The number of firms backing the undertaking was 141 initially, but has now risen to 157. Reaktor A.G., which is on a non-profit-making, co-operative basis, also receives substantial financial support from the Federal Government.

Following the atomic energy exhibition held in Geneva in 1955, it was decided to acquire the " swimming pool " reactor exhibited on that occasion, and to redesign it for erection at Würenlingen in a way which would facilitate the carrying out of experimental work. The necessary laboratory, workshop and personnel facilities were also to be provided. The foundation stone was laid on April 17, 1956, and the first trial of the completed reactor took place on April 30 of this year. The reactor was officially inaugurated on May 17.

For various reasons—stability, accessibility, ease of handling and moderate cost—the " swimming pool " design of reactor is very suitable for research and development work. It will be recalled that the first reactor of this kind was built at Oak Ridge and became critical in December, 1950. The core of a " swimming pool " reactor consists of slightly enriched uranium elements which are submerged in ordinary water which acts as moderator, reflector, and radiation shield. This last fact allows the core to be observed directly during manipulation, which greatly facilitates the handling. The reactor is stable, because any over-activity at once turns some of the water around the fuel elements into steam, thereby reducing the amount of moderator and so decreasing the neutron density. Because of the blue glow around the core, the Würenlingen reactor has been named " Saphir " (sapphire).



The walls of the tank are of barytes concrete and stepped, with maximum thickness of 2·5m. Near the base can be seen four of six openings (normally closed by lead plugs) from which neutron beams emerge into the laboratory

Site.—The site for the new reactor is on the River Aare, some 1200m above the weir of Beznau power station belonging to Nordostschweizerische Kraftwerke A.G. The plot measures some 1000m by 200m. Under 50cm to 100cm of humus and clayey sand there are 10m of gravel, resting on marl and limestone. The ground slopes slightly from 335m above sea level at the forest edge to 330m at the river bank, then drops away steeply to the water 5m below.

Constructional Work.—The accommodation comprises the reactor building with adjoining laboratory, workshop, lecture room, staff rooms (for operating on two shifts later), and canteen. Extensive drainage was also required.

Construction involved an earth movement of 10,000 cubic metres and the placing of 2000 cubic metres of concrete and 160 tons of steel reinforcement. A maximum labour force of seventy men was employed, and a total of 110,000 man-hours of work was carried out. This is in addition to the preparatory planning which occupied six months.

Reactor.—Until the completion of the EL3 reactor at Saclay, the " Saphir " will be the most powerful source of neutrons on the Continent of Europe, giving an internal flux of nearly 10^{13} neutrons /sm^2/sec, while the flux available in the experimental channels can reach several hundred million neutrons per square centimetre per second.

The core consists of twenty to thirty fuel elements, the number being varied to suit the required output, which may reach 1000kW or more. Each fuel element measures 10cm by 10cm by 1m and is built up of eighteen plates, each of which contains about 170 grammes of U235, corresponding to a 20 per cent enrichment of the natural uranium. Three of the elements are hollow and act as controls. The fuel elements are inserted in a baseplate drilled with equidistant holes. They can readily be placed in position or removed.

The core is placed near the bottom of a water tank 8m long by 3m wide by 8m deep, holding 200 cubic metres of ordinary demineralised water. The baseplate on which the elements are mounted is suspended from a vertical arm which in turn is mounted on a bridge over the tank. The rails on which the bridge moves are on top of the longitudinal walls of the tank, which at this point are 40cm thick. They have been given an internal plastic coating to protect the concrete and to increase the amount of reflected light and so make observation easier.

Towards the base, the wall thickness increases in three steps, so as to form a radiation shield which is up to 2·5m thick and is made of barytes concrete of density 3·5 tons per cubic metre (the barytes having a density of 4 tons per cubic metre). The design is illustrated opposite.

The reactor is situated in the centre of the building. Branching off to one side is the radiation laboratory, into which neutron beams can be conducted through four radial openings and one duct

A central control room serves the whole installation. It is on the same level as the top of the tank, which the controller is able to survey through the windows of the control room

passing right through the reactor. These ducts are formed by double-walled aluminium tubes which, when not in use, are closed by heavy lead plugs.

Setting up of radiation experiments within the tank is facilitated by a watertight bulkhead by means of which the tank can be divided into equal halves. The half containing the core remains full while the other can be drained.

Controls are provided for checking the radiation level at three points, near the core, above the water level over the core, and in the reactor hall. If the radiation at any of these stations becomes excessive the plant is shut down automatically. All controls are concentrated in the control room, illustrated on this page, from which a full view of the reactor is obtained.

Auxiliary Plant.—Special tanks are provided for the storage of used fuel elements while their radioactivity is allowed to decay. Of fundamental importance to the correct and safe functioning of the reactor is the demineralising plant. This removes all dissolved substances from the feed-water for the tank. Such substances would become radioactive near the core and would cause contamination. This plant operates on the ion-exchange principle and has a capacity of 3·5 cubic metres per hour. A similar plant of 4 cubic metres per hour capacity is installed for the continuous demineralising of the water.

Among the tasks of the "Saphir" reactor team, which at present comprises fifty scientists and engineers, will be research for Swiss firms undertaking atomic development work and consulting engineering in this field. It will be necessary to work out rules and regulations for the safe construction and operation of reactors; advice will be given to the government in this sphere and also in connection with problems of atomic warfare. Besides materials testing and the manufacture of radio-isotopes, the Centre will be engaged in the training of post-graduates who wish to become atomic technologists, and will also collaborate in the research field. An agreement to this effect has already been concluded with E.T.H., Zürich. In addition, the experience gained is proving very valuable for the construction of a second reactor, which is also being built at Würenlingen. This design will use heavy water.

The direction of the building work at Würenlingen was in the hands of Motor-Columbus A.G., Baden, which also carried out the cooling water intake, drainage system, restaurant and access road. The reactor building, laboratory, maintenance workshop and electricity supply were in the hands of Elektro-Watt A.G., Zürich, while control equipment is by Landis and Gyr, Zug. The building contractor was Bertschinger A.G., Baden.

Alternative Power Locomotive

For such applications as opencast mining or works railways, a locomotive which can be run alternatively on electric or diesel power may be found advantageous. The accompanying illustration shows such a unit which has recently been put on the market by Henschel and Sohn G.m.b.H., Kassel, German Federal Republic. The locomotive is for a gauge of 900mm and weighs 27 tons. Its two axles are each driven from one side through reduction gearing by a nose-suspended traction motor. The two 1200V motors have hourly ratings of 107kW each at 580 r.p.m. As an alternative power source there has been installed a diesel engine of 145 h.p. which drives a 106kW generator (continuous ratings). This unit is housed in one of the end compartments, while the other contains the electrical resistances, switchgear and the compressed air plant. The driving cab is situated in the centre.

The frame is all-welded. Special heavy combined buffers and couplings, hose couplings for brake piping, and rail guards are fitted at both ends. With a wheelbase of 2500mm, the length over buffers is 7700mm. Maximum tractive effort at starting is 8000 kg, maximum speed approximately 30 km per hour. In addition to the main pantograph, the locomotive is equipped with lateral pantographs, which are adjustable for different positions and heights of the conductor wire. These are used when the conductor wire has to be placed on one side, as when excavators or conveyors are used to load the wagons.

213kW, 27-ton, 900mm gauge dual power locomotive. Maximum tractive effort 8000 kg, maximum speed 30km per hour

Dechema 1956 Annual Report

The first part of the 1956 Report of Dechema Deutsche Gesellschaft für Chemisches Apparatewesen, Frankfurt/Main, presents a full picture of the various activities of this society, which operates as an information centre for the benefit of its members. The report contains an account of the lectures organised by Dechema, the journals *Chemie-Ingenieur-Technik* and *Werkstoffe und Korrosion*, the Dechema Monographs, the *Erfahrungsaustausch*, the *Dechema-Werkstoff-Tabelle* (third edition) and other publications. It also gives information on the Dechema committees which have been formed with the object of encouraging and fostering research and development in the various branches of chemical engineering and technical chemistry.

Dechema and the Max-Büchner-Forschungsstiftung, which is managed on an honorary basis by the former, contributed a sum of about DM158,000 to promote research and developments in 1956.

The detailed report on the Dechema-Institut für Apparate- und Stoff-kunde shows the substantial development which has taken place since its formation in 1953. The means of documentation provided by this institute represent a valuable contribution to the rationalisation of mental effort.

The activities of the Max-Büchner-Forschungsstiftung are covered by the second part of the report. A grant of DM57,550 was made in 1956 towards the cost of eighteen research programmes, the results of which are reported.

Dechema has continued its practice in previous years of reviewing papers published during 1955 on the fundamentals of chemical technology and kindred sciences. The report concludes with a list of DIN Standard Specifications* which have been drafted in collaboration with Dechema.

Extension of Frimmersdorf Power Station

Frimmersdorf thermal power station of Rheinisch-Westfälisches Elektrizitätswerk A.G., Essen, which at present is equipped with one 100MW set, is being extended by the addition of two 150MW turbo sets; two further similar sets are to follow by 1960. All are by Brown Boveri et Cie, Mannheim.

* Available free of charge on application to Dechema Deutsche Gesellschaft für chemisches Apparatewesen, Frankfurt (Main) 7, Postfach.

U.S. Army Package Power Reactor in Virginia

BY OUR AMERICAN EDITOR

No. I

The 1925kW "Army Package Power Reactor" (APPR) recently went into operation at Fort Belvoir, Virginia, and is the first nuclear generating station of the U.S. Army. It is the first prototype of a family of nuclear power plants under development by the U.S. Atomic Energy Commission and the U.S. Department of Defence for use by the three military services. The concept envisages that the components will be transportable by air and capable of erection at a remote field site in a six-month construction period. The reactor is of the pressurised water, light water moderated design and uses fully enriched uranium fuel.

WHEN the U.S. Army is mentioned in connection with nuclear power plants, the questions arise: "Why is the Army interested in nuclear power and what is it doing in this field?" To answer these questions, one has to take into consideration: (1) the military advantages of this relatively "fuel-free" heat source; (2) the many potential military applications of nuclear power, and (3) the joint U.S. Army-A.E.C. programme developing a "family" of reactors to exploit the full potential of the application of nuclear power to military requirements.

The military advantages of nuclear power are derived primarily from logistic considerations. Since nuclear power plants can be built to operate over extended periods of time without refuelling, the great military advantage of such power plants is the elimination of all but a small fraction of the logistic effort which otherwise would be required to transport and store bulky conventional fuel. For example, the APPR is designed to operate at full power for a year and a half on a single charge of nuclear fuel, which weighs only a few hundred pounds. Over the same period a comparable conventional power plant would consume some 60,000 barrels of fuel oil, equivalent to the capacity of a medium-size tanker. Even under peacetime conditions, the transport savings are expected to counterbalance the greater capital cost of a nuclear plant, so that at many remote bases the nuclear plant will pay for itself in a few years. Furthermore, as a consequence of this reduced logistic load, military operations are less dependent on long lines of supply and, therefore, less vulnerable to enemy action. In addition, operations are more flexible since additional blocks of power may be brought in without significant increases in logistic effort. The ultimate availability in mobile sources of more electrical power than heretofore available will substantially affect future military planning wherever a high degree of mobility is a decisive factor. These advantages are much more obvious now than they were in 1952, when the U.S. Army, in co-operation with the A.E.C., initiated its nuclear power programme. At that time, the Army embarked on a number of studies, including an analysis of the overall power requirements at military bases and in military theatres of operations and an objective evaluation to determine which of these power requirements could be met to the greatest advantage by the use of nuclear power plants. The investigations showed that at some remote and inaccessible arctic installations, the cost of generating power was five to ten times greater than at large steam power station plants in the United States. This cost differential represents the logistical effort to build these bases and supply them with fuel at peacetime costs. Under wartime conditions, the A.E.C. called upon the Oak Ridge National Laboratory (O.R.N.L.) to work with the U.S. Army Corps of Engineers in developing a nuclear reactor design which might be applicable for military use. In order to capitalise on the military advantages of nuclear power plants, certain general development objectives were established. These objectives included the development of plants that will be transportable by air, as a whole or by components; be simple and safe to operate; operate for at least a year without refuelling and with a minimum of shut-down time and maintenance; use standard components; have semi-automatic power level control, and be economical to build and operate from the standpoint of both funds and critical materials. At that time, all of the reactors built or being built in the United States were designed for weapons material production, experimental research and training, or nuclear propulsion. These reactors covered a wide range of concepts and designs. It was, of course, desirable that military nuclear power plants should take maximum advantage of existing reactor technology. The O.R.N.L. evaluated the existing reactor concepts and concluded that the heterogeneous, pressurised-water reactor offered the greatest promise of satisfactory performance in the minimum time. The laboratory prepared a conceptual design, which later became the basis for the design of the APPR.

In 1953, upon the request of the Corps of Engineers, the Operations Research Office of Johns Hopkins University, performed a detailed analysis of the feasibility of the O.R.N.L. preliminary reactor design for use as a source of power and heat at an arctic installation. This group approached the problem with the objective of analysing the military cost of supplying power and heat at a typical arctic station, both with conventional equipment and with a nuclear plant, and comparing the two in detail. As a result of these studies, a military requirement was established by the Joint Chiefs of Staff for the development of nuclear power plants for use in remote and relatively inaccessible locations. The Secretary of Defence assigned to the Army the responsibility for representing the military services in carrying out the resultant research and development programme with the A.E.C. Following the approval of the military requirements by the Secretary of Defence, the joint Army-A.E.C. programme established under these agreements has the objective of developing a family of nuclear power plants to meet the needs of the three armed services. The plants are to provide power at remote and inaccessible sites, devastated areas, combat zones and disaster areas in the United States. The larger plants will be capable of use in areas where logistical support to meet conventional fuel requirements is difficult, costly, or vulnerable to interruption by enemy action or at vital installations where the necessity of uninterrupted power warrants the additional initial costs. Smaller stations are to be developed as mobile or semi-mobile compact power plants to be mounted on or transported by standard equipment for the support of military operations and for emergency power requirements.

Research and Development Programme

The programme covers military applications of nuclear power other than ship and aircraft propulsion and embodies three general categories of military nuclear power plants: fixed, mobile and semi-mobile, and special-purpose installations. Besides the APPR, the first category at present includes the Argonne Lower Power Reactor (ALPR), designed for use at smaller installations. Construction of the ALPR prototype plant will be started soon at the National Reactor Testing Station at Idaho Falls, Idaho. The ALPR will employ a heterogeneous, boiling water reactor and will produce approximately one-tenth the power of the APPR.

In the second category, development has begun on mobile and semi-mobile plants for the support of military operations and for emergency power systems. The objective is to develop plants which can be carried on trailers, railway cars or barges, and do not require the replacement of fuel or water for the duration of military operations. Two major projects are now under way leading to prototype development. The A.E.C. has initiated the development of a Gas-Cooled Reactor Experiment (GCRE) to be constructed at the National Reactor Testing Station in Idaho. Furthermore, the U.S. Army Engineer Research and Development Laboratories are contracting for the construction and test operation of a closed-cycle gas turbine test facility at Fort Belvoir, Virginia.

The third category covers special-purpose nuclear reactor systems. Studies are being conducted in the nuclear propulsion of land vehicles, with the Army Transportation Corps directing particular attention to a nuclear-propelled, overland cargo carrier. Another special purpose reactor is under consideration to provide a source of gamma radiation for use

by the Army Quartermaster Corps in its food preservation programme.

However, since the most pressing military requirement was for the development of plants suitable for use at remote military bases, the APPR was the first development project undertaken. In the latter part of August, 1954, the Department of Defence and the Atomic Energy Commission announced that they would jointly undertake the design and construction of a full-scale prototype nuclear power plant to be built at Fort Belvoir, Virginia. In this joint effort, the Army and the A.E.C. sought to stimulate further and take advantage of the great interest of private industry in nuclear power. Early in 1954, the A.E.C. invited expressions of interest in package power plant development on a lump-sum basis from a large number of firms. Replies were received from approximately 100 firms. An A.E.C. Contractor Selection Board evaluated the replies and qualifications of the interested firms and selected thirty-three firms or industrial teams which appeared best qualified to undertake the project. These thirty-three firms were invited to submit proposals for the design, construction and test operation of the prototype package reactor power plant. Eighteen proposals were received late in November 1954. The evaluation of the proposals from a standpoint of price, suitability of design, and responsiveness to other details of the invitation, resulted in the awarding of the contract to the then American Locomotive Company (now ALCO Products, Incorporated), of Schenectady, New York, in December, 1954. The contract price was shared by the A.E.C. and the Department of Defence.

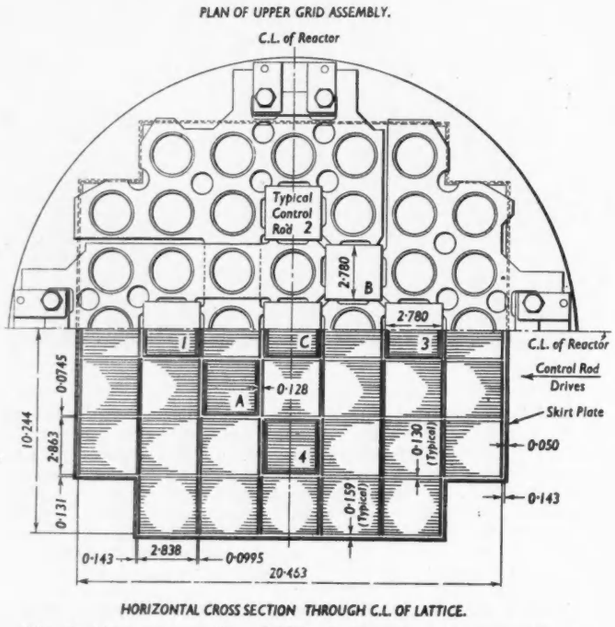


Fig. 1—Core cross section of U.S. Army package power reactor at Fort Belvoir

The major objectives to be accomplished by the APPR are : (1) to solve technical construction and operation problems associated with a reliable nuclear power plant ; (2) to provide firm cost information, operating parameters and the engineering test data necessary to adapt the system to a remote location and to improve operating characterisitcs ; (3) to provide a training facility for troops and specialists who might eventually be required to operate and service such plants.

Reactor Design

In accordance with the present design the reactor will be operated at a heat rate of approximately 10,000 B.Th.U. per second, and the generator will deliver 2105kW with the condenser cooling water at the conventional temperature of 70 deg. Fah. Since the average station services amount to 180kW, the net station output is 1925kW, equivalent to an efficiency of 19¼ per cent. The basic shielding of the reactor is achieved by an iron-and-water layer shield. Since the availability of aggregate for a concrete shield could not be relied upon at any and all possible future sites, the iron-water system was selected, for it reduced the total weight to be transported in areas where aggregate was lacking. In the event of a major system rupture the containment of contaminated vapour is provided by a container 36ft in diameter and 64ft high. The enclosed volume will contain all of the steam generated by the flashing of the superheated primary and secondary system water volumes. The use of this structure necessitated some special care in the method of handling spent fuel. When the reactor is refuelled spent elements are removed, under water, to a catch basin at the bottom of a deep water-filled storage pit outside the vapour container. Thus, not only are the fuel elements at all times accessible from the outside for removal to a reprocessing plant, but they are also available to return to the reactor if it is desired to perform additional test work.

As shown in Fig. 1 the reactor design is a 20½in square with the corner elements removed in order to approximate a cylinder. There are forty plate fuel elements of stainless steel and enriched uranium, 2¾in square and 22in in active length. Five control rods are employed, four of which are operated in unison as a shimming control. The fifth or central rod is used for close control in adjusting to the hourly variation of the reactor. All of these are operated without servo controls since the reactor has a high negative temperature coefficient and, hence, is highly stable. The reactive portions of the fuel elements are fitted with inlet and outlet end boxes, so that the overall fuel element length is nearly 3ft. As shown in Fig. 2, they are held in position by a top and bottom grid, both of which are supported from a diaphragm within the thermal shield, which, in turn, is supported by an internal flange in the upper portion of the pressure vessel. The core is contained within a reactor vessel 4ft in diameter and 8ft 5in high. Cooling water is introduced immediately below the flange which supports the reactor and serves to direct the water to the entrance plenum chamber at the bottom of the reactor vessel. From the bottom the water flows upward through the fuel elements to the exit plenum chamber, from which the exit nozzle leads the water to the steam generator. When fuel is to be changed the reactor cover plate is removed after which the upper retaining grid can be removed, which exposes the fuel elements and the control rods. The well above the reactor is filled with water at all times so that the fuel elements are always submerged at least 12ft. This depth of water provides enough shielding to prevent over-exposure of personnel working on the platform at the top of the tank during the short period that fuel elements are actually being transferred. Fig. 2 indicates the fuel transfer tube with its inner end immediately above and to the left of the reactor vessel, communicating diagonally with the catch basin at the bottom of the spent fuel pit which is outside the vapour container. The fuel elements are passed one at a time through this transfer tube to the bottom of the spent fuel pit and stored individually in holders in the bottom of the pit, which are provided to keep the fuel elements from assuming a critical geometry.

Fig. 3 also shows the primary shield around the reactor, which consists of light layers of iron 2in thick in a water tank 47in thick radially. The resulting neutron attenuation is considered to be more than adequate for radiological safety purposes. The gamma attenuation of this shield is also sufficient to reduce the radiation leaking from the core to a level equal to that due to the primary coolant water in the pipes and steam generator. The additional shielding is accomplished by the 7ft thick concrete lining of the vapour container, supplemented by an additional 3ft outside of the vapour container in the operating levels. This additional thickness reduces the radiation level in continuously occupied areas to values of the order of 20 per cent of the accepted maximum values.

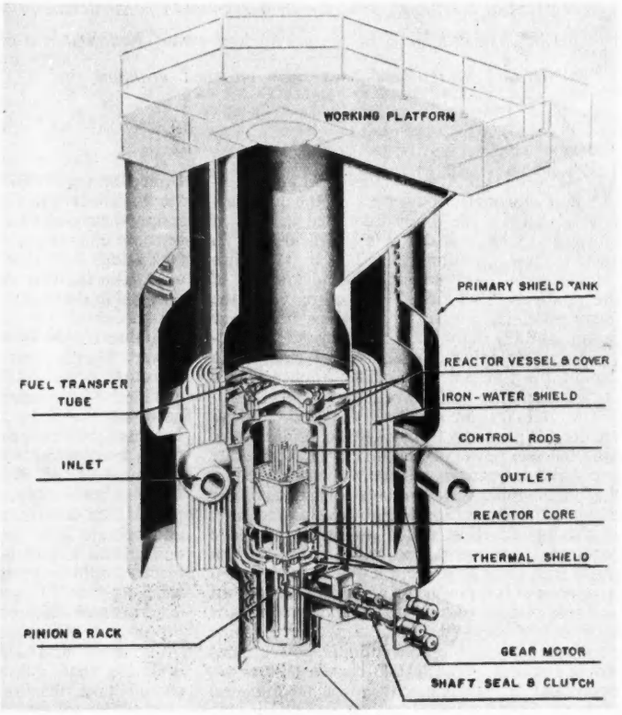


Fig. 2—Sectional view of U.S. Army package power reactor showing reactor vessel and primary shield

The control rod drive is situated below the reactor vessel, resulting in two important advantages. First, the rod actuating mechanism is completely independent of the cover plate ; hence, no possibility exists for opening of the pressure vessel to precipitate a nuclear incident by withdrawal of control rods. Secondly, the major part of the drive system is made more readily accessible for maintenance and adjustment. The control rod consists of a square, hollow basket structure into which removable fuel and absorber portions are inserted. Each of these two units is equal in length to the active length of the core. With this design, the consumable portions can be removed and replaced without disturbing the mechanical adjustments of the control rod drive system. Integral with the basket structure at its bottom end is a 1in dia-

meter extension, machined to provide a rack. A pinion engages this rack and is driven by means of a shaft which brings the shaft seal well out to the side and into an area where the radiation intensity is low enough to ensure that induced activity is harmless. The seal itself is a labyrinth disc seal with clean water introduced near the inner end. A slow inward leakage of pure water occurs under a slight pressure differential between the pure water and the outside atmosphere. The existence of the buffer zone of pure water assures that no radioactivity leaks through the shaft seal. A magnetic clutch is used to obtain quick disengagement of the rod and drive motor so that the rod may be released to fall under the action of gravity. By minimising the rotating inertia, an acceleration of $\frac{1}{4}g$ is obtained despite the buoyant effect of the water displaced by the rod.

Steam Generating Plant

As shown in Fig. 3, in the primary cycle of the plant, 4000 gallons per minute of water are circulated through a closed loop consisting of the reactor and the steam generator with connecting piping. Water leaves the reactor at 450 deg. Fah. and enters the steam generator, passing through U-tubes which are surrounded by the boiling water in the secondary circuit. The primary water is cooled to 431 deg. Fah. at full load, and after leaving the steam generator, is returned to the reactor by one of two "canned rotor" motor-driven coolant pumps. The Y-connection between the pump outlets is provided with a balanced swing check valve which remains in the closed position on the idle pump. A small back flow is provided, in order to prevent the "dead" leg from cooling more than 10 deg. below the operating leg. This prevents a "slug" of cold water from entering the reactor as a result of energising the stand-by pump.

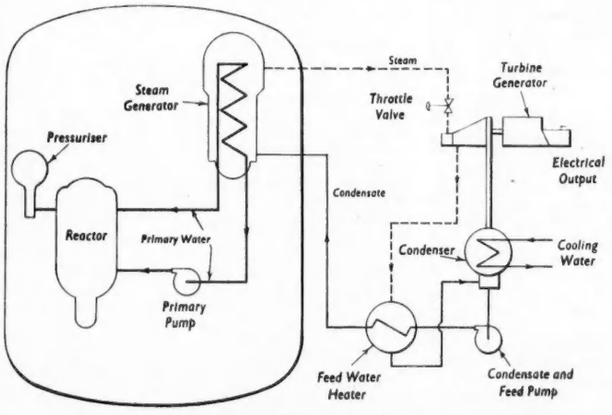


Fig. 3—Simplified flow diagram of U.S. Army package power-reactor plant

Pressure is maintained at the 1200 lb per square inch operating level in the primary coolant circuit by a steam pressuriser vessel containing two 50kW heaters, which may be operated in increments of 10kW. The units are controlled from individual thermostats so that, as surges in the primary system progressively depress the temperature, additional elements are taken into service to increase the rate of return to equilibrium. The pressure of 1200 lb per square inch provides insurance against boiling in the reactor during all normal operations. The hottest surface metal temperature in the reactor is below the steam saturation temperature of 567 deg. Fah., even after allowing for the effect of some fouling of the transfer surfaces.

Steam is formed in the steam generator shell at 200 lb per square inch absolute at full load. At the normal heat transfer rate in the steam generator the steam is superheated 25 deg. to reduce condensation in the last turbine stages. At decreasing loads, due to the constant primary coolant temperature, the temperature on the secondary steam side approaches 450 deg. Fah., so that at no-load steam will be generated at 423 lb per square inch absolute. The turbine is designed for a 250 lb per square inch gauge inlet pressure, to provide operating margin for the increased inlet pressures at partial loads. A pressure-reducing valve is provided which will throttle the steam to maintain a 250 lb per square inch gauge line pressure as decreasing load causes the steam generator pressure to rise above 250 lb per square inch gauge. A safety valve ahead of the pressure reducing valve protects the steam generator, and a safety valve following the pressure reducing valve protects the turbine against over-pressure. The steam generator and steam turbine are connected with a single 8in diameter carbon steel pipeline, which restricts line pressure drop to only 10 lb per square inch, so that the full load turbine inlet pressure will be 190 lb per square inch absolute.

Steam from the turbine is exhausted to a deaerating surface condenser. Combined vertical hotwell and feed pumps are employed for the condensate return, thus avoiding the use of two sets of pumps. A steam-driven emergency pump is provided for feeding the steam generator during loss of electric power. In addition to the normal considerations, this pump is useful in keeping a load on the steam generator as a means of removing decay heat from the reactor. The condensate is returned to the steam generator through the condensing side of the main condenser air ejector and the feed water heater, which at full load raise the temperature to 250 deg. Fah. The main source of heat for the latter unit is steam extracted from the turbine at 35 lb per square inch absolute, although some economy is achieved by using the steam from the make-up evaporator to supplement the extracted steam. Circulating water for the condenser and cooling water for auxiliary services are taken from Gunston Cove on the Potomac River. A water pump well with dredged inlet has been built in the shallow cove to ensure a supply of water at all tide levels. Water is circulated by one of two motor-driven vertical submerged pumps. The circulating water is discharged from the condenser to a seal pit, in order to maintain as high a vacuum as practicable at the condenser water box.

Water Treatment

Water treatment in both the primary and secondary systems of the Army Package Power Reactor is important to the successful operation of the nuclear generating plant. The principal water system is the primary water system, which is demineralised and contains an excees of hydrogen to deter corrosion. From the nuclear standpoint, the exceptionally high purity of the primary system water is necessary to reduce to a minimum any possible radiation hazard. From the mechanical standpoint, impurities could eventually clog the many close-tolerance mechanisms in the system, and could cause difficulties if deposited on fuel elements. It is now well known that certain reactions are present under the influence of a high radiation source that are not a factor without radiation. When water is subjected to radiation, it dissociates to form free oxygen and hydrogen. Under particular conditions of pH and the gases present, the formation of either ammonia or nitric acid also occurs. For these reasons, severe water-purity requirements were imposed in the primary system. It limits not only the amount of solids but also the quantity and type of gases to maintain stringent specifications.

With continuous purification of a portion of the primary water in the APPR, the total solids content is maintained at a maximum of 2 p.p.m. The water requiring purification is referred to as blow-down. This blow-down is taken from the primary loop downstream from the steam generator at about 431 deg. Fah., and the pressure is reduced to 100 lb per square inch absolute by a throttling valve. The blow-down water is then passed through one of two mixed-bed demineralisers, where most of the impurities are purged. It is then collected in a stainless steel tank and from there recirculated to the primary loop by the make-up pumps. These pumps also supply water to the control rod seals.

The most significant difference between the equipment of a conventional power station and a nuclear plant is the boiler. Should a tube failure or a leak occur, radioactive primary water will enter the secondary system and cause a potential radiation hazard to the operating personnel. Therefore, the need for the treatment of the secondary water in a nuclear system to prevent the corrosion of the boiler tubes is more pronounced than in a conventional system. To maintain the high purity of the primary water, the APPR employs a stainless steel generator; this has the disadvantage of magnifying the possibility of chloride stress corrosion from secondary water. Despite the fact that chloride concentration in the boiler may be low, concentration cells may be formed in the crevices. Most investigators agree that chloride stress corrosion cannot occur unless oxygen is present and, although the threshold amounts of either oxygen or chlorides have not been defined, it is reported that even trace amounts of oxygen are sufficient to favour such corrosion. Chloride control imposes severe restrictions on the construction and operation of the secondary system. The chloride concentration at the APPR has been established at 0·5 p.p.m., and with a nominal blow-down rate of 1 per cent, the feedwater must not exceed 0·005 p.p.m. of chloride.

The only make-up water required after start-up of the system is that needed to replace blow-down and unaccountable leakage. Make-up water is prepared from Fort Belvoir service water, which has a hardness of 45 p.p.m. as $CaCO_3$ and 85 p.p.m. dissolved solids, of which 8·5 p.p.m. are chlorides. This water is used principally as feed for the evaporator. The distillate from the evaporator does not exceed a total solids content of 1 p.p.m., of which chloride content is about 10 per cent. The distilled water from the evaporator is stored in a 5000 gallon tank, and used as make-up for the primary and secondary systems, as coolant for the primary circulating pumps, coolant for shield water and in the spent-fuel pit. The make-up water for the primary system is processed through demineralisers before use. Ordinary power station practice is employed in the use of chemicals to control the secondary water systems. A deaerating hotwell produces water with 0·003 cubic centimetres of oxygen per litre, and to reduce this amount further, hydrazine phosphate and morpholine are added to the boiler feed. The spent fuel pit contains about 16,000 gallons of water that may become dirty, cloudy or contaminated with algae. To alleviate this problem, the water is circulated periodically through a diatomaceous earth filter.

(*To be continued*)

Design for 133MW Atomic Power Station

The Babcock and Wilcox Company, of New York, has made public its design for a nuclear steam generating system which would satisfy the requirements of electric utility companies of foreign nations, who are in the market for atomic power stations. As described to a group of sixty European industrialists and government officials during a recent visit to the firm's nuclear facilities plant at Lynchburg, Virginia, the pressurised water reactor design developed is suitable for a utility plant of about 133MW electrical capacity. Using thermal energy generated by fuel elements containing slightly enriched uranium, the nuclear plant would produce nearly 2,000,000 lb of steam per hour to drive a turbo-generator set. It was also indicated that the steam generating capacity and electrical output of the plant might be increased, if desired, by means of a steam superheater burning conventional fuels.

The proposed reactor uses light water as the moderator and transfer heat medium between the fuel elements and a steam raising heat exchanger.

Personal and Business

Appointments

MR. G. B. PARTRIDGE has been appointed development officer of William Mills, Ltd., Wednesbury.

MR. W. R. WINFIELD has been appointed technical sales manager of Towler Brothers (Patents), Ltd., Rodley.

LORD BRABAZON OF TARA has been elected president of the Radio Industry Council in succession to Sir Edward Appleton.

THE DRAYTON REGULATOR AND INSTRUMENT COMPANY, Ltd., has announced that Mr. W. A. Flint has joined its sales promotion department to handle publicity.

THE BRITISH STEEL CASTINGS RESEARCH ASSOCIATION has announced that Mr. Russel H. Brown has joined its research staff as a senior investigator in the plant engineering section.

MR. N. G. BASSETT SMITH, who has been promoted to the post of general manager of the Dunlop compositions division, will take charge of the company's new factory between Fort Dunlop and Castle Bromwich.

CANADIAN PACIFIC RAILWAY COMPANY has announced that Mr. L. B. George has been appointed chief of motive power and rolling stock. Mr. W. D. Dickie has been appointed assistant chief of motive power and rolling stock.

THE MINISTER OF TRANSPORT AND CIVIL AVIATION has appointed Mr. Laurence J. Culshaw, F.C.A., and Mr. Jocelyn F. T. Nangle, F.C.A., to be auditors of the accounts of the British Transport Commission for the year ending December 31, 1957.

MR. EDMUND BRUCE BALL has been appointed managing director of The Lilleshall Company, Ltd., Nr. Oakengates, Salop, and of its subsidiary companies. He succeeds the late Mr. Alexander Oxley, and will assume his duties on October 1, 1957.

WADKIN, Ltd., Leicester, has announced the appointment of two technical representatives. Mr. H. D. Kettle will cover the Birmingham, West Midlands, South Wales and South-West England area. Mr. J. O. Fisher will cover the East Midlands and East Riding of Yorkshire area.

THE UNITED STEEL COMPANIES, Ltd., announces that Mr. L. Webster has been appointed production manager (engineering) of Distington Engineering Company, Ltd. Mr. Colin Scott has been appointed personnel manager of Distington Engineering Company, Ltd., in succession to Mr. J. P. Pearson who has joined the department of operational research and cybernetics of the United Steel Companies, Ltd., as a specialist on labour relations.

Business Announcements

SPENCER-BONECOURT-CLARKSON, Ltd., states that it has moved to 28, Easton Street, London, W.C.1 (telephone : Terminus 7466).

W. H. BIRD AND SONS, Ltd., Bristol, states that it has opened a London office at 44, Tower Hill, London, E.C.3 (telephone : Royal 1461).

CANADIAN PACIFIC RAILWAY COMPANY has announced that Mr. F. A. Benger, chief of motive power and rolling stock, has retired after serving the company for forty-six years.

MILLS SCAFFOLD COMPANY, Ltd., states that it has concluded an agreement whereby its range of scaffold fittings will be manufactured under licence and marketed in Spain by Andamiajes Mills S.A. (Amillsa), Hermosilla 19, Madrid.

THE BENSON-LEHNER CORPORATION of Los Angeles announces that its new British subsidiary—Benson-Lehner (G.B.), Ltd.—has taken over many of the functions of Benson-Lehner's British division, at 12, Bargate, Southampton. The new company will continue the supply and maintenance of a wide range of scientific data processing equipment, including analysers for strip chart records and cine film, automatic graph plotters.

Contracts

THE GENERAL ELECTRIC COMPANY, Ltd., has been awarded a contract by the U.K. Atomic Energy Authority for a large part of the design and construction of a Zero Energy Assembly for a new type of gas-cooled reactor. It is intended to build this equipment at the Authority's proposed new research station at Winfrith Heath. This Zero Energy Assembly is the first stage in the development of a high temperature reactor system in which fuel temperatures will be raised well above those possible in present designs. The resultant higher gas temperature should enable electricity to be produced more efficiently by conventional steam turbo-generator plant or possibly by gas turbines. The Zero Energy Assembly will be used primarily to examine the nuclear properties of the system and to verify design calculations before proceeding to a power reactor. It is so designed that the nuclear reactions will take place at a very low rate and very little external radiation or heat will be produced.

METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., has received an order from the Electricity Supply Commission of South Africa for two 60MW turbine-generator sets and associated condensers and feed-water heating equipment, for a new extension to Umgeni power station, about 10 miles north-west of Durban. The first generating set is due for delivery in February, 1960, and the second in February, 1961. The turbine-generators will be manufactured at the Metropolitan-Vickers Trafford Park Works and the feed-water heating equipment at the M.-V. Germiston works, Glasgow ; steam condensers will be to Metropolitan-Vickers design, the condenser shells being made in South Africa. The turbines will be conventional two-cylinder machines, with inlet steam at 600 lb per square inch gauge, 850 deg. Fah. The generator rotors will be direct air cooled, air being circulated by integral fans through the slotted copper windings.

THE CENTRAL ELECTRICITY AUTHORITY has placed contracts during the past month for power stations, transforming stations and transmission lines amounting in the aggregate to £7,761,400. The principal contracts include : Drakelow "B" power station, Burton-on-Trent, foundation extension, M. J. Gleeson (Contractors), Ltd.; Spondon "H" power station, near Derby, structural steelwork, Edward Wood and Co.,Ltd.; Skelton Grange "B" power station, Leeds, one 120MW turbo-generator and feed water heating plant, C. A. Parsons and Co., Ltd., and condensing plant, G. and J. Weir, Ltd.; Padiham "B" power station, near Burnley, two 120MW reheat boilers Babcock and Wilcox, Ltd.; Rheidol hydro-electric scheme, access roads and preliminary works, Sir Alfred McAlpine and Sons, Ltd.; Carrington–Old Hall Road and Portishead–Churchill/Bridgwater and the Northfleet power station, 132kV overhead lines, W. T. Henley's Telegraph Works Company, Ltd.; Belvedere sub-station, near Erith, 132kV, 3·3kV and auxiliary cables, British Insulated Callender's Cables, Ltd.; Yarmouth substation, 132kV switchgear, Metropolitan-Vickers Electrical Company, Ltd.; Southport substation, two 60MVA, 132/33kV transformers, Ferranti, Ltd.; Hams Hall–Melksham, 275kV overhead line, British Insulated Callender's Construction Company, Ltd., and Tilbury–Basildon, 132kV overhead line, J. L. Eve Construction Company, Ltd.

Miscellanea

SMALL BENCH PRESS.—An air-operated bench press made by Kerry's (Engineering Company), Ltd., Grange Road, Leyton, London, E.10, has a capacity of ¼ to 1½ tons, working on an air line pressure of 70 lb per square inch. It has an open height of 4½in with an adjustment of ¼in ; its stroke is 1 1/16in. The press is suitable for blanking, riveting, piercing or broaching operations, and can be supplied with foot, hand or guard operation.

GENERATING SETS AND POWER PACKS.—Henry Meadows, Ltd., has introduced a new range of generating set equipment, together with a scheme of standardised parts and extensive interchangeability. The scheme reduces these multi-purpose sets to three basic denominations and the complete range is based on the company's six power units with outputs from 22kW to 161kW in the generating set range and from 36 to 270 b.h.p. for power packs.

SHELL ROOF CONSTRUCTION IN TIMBER.—A description of an anticlastic shell roof built in timber at Wilton, near Salisbury, was published in our issue of July 26. The roof consists of three layers of boarding, and we stated that "the lower and middle layers adhere with Bostick." In fact, the edges of the bottom layer were fixed with ordinary metal staples, such as are used for fixing paper together, the machine used being called a "Bostitch."

RADIO COMPONENT SHOW, 1958.—The fifteenth annual Radio Component Show, organised by the Radio and Electronic Component Manufacturers' Federation, is to be held at Grosvenor House and Park Lane House, London, W.1, from April 14 to April 17, 1958. Admission (from 10 a.m. to 6 p.m. daily) is by invitation only and applications for tickets should be made to the Secretary, Radio and Electronic Component Manufacturers' Federation, 21, Tothill Street, London, S.W.1.

PROBLEMS OF AIRCRAFT PRODUCTION.—The sixth annual conference on Problems of Aircraft Production, promoted by the Southampton Section of the Institution of Production Engineers, will again be held at the University of Southampton on January 2 and 3, 1958. The theme will be "U.S. and U.K. Practice." The conference will be opened by the presentation of the third Lord Sempill paper, which will be given by Mr. Boyd K. Bucey, assistant to vice-president, manufacturing, the Boeing Airplane Company.

WILLINGTON "B" POWER STATION.—The Central Electricity Authority has received the consent of the Minister of Power to the extension of Willington power station, Repton, Derbyshire, by the installation of two 200MW turbo-generators and two 200MW reheat boiler units in the "B" section. Each boiler will have a capacity of 1,400,000 lb of steam an hour. In Willington "A" station, now under construction, there will be four 100MW turbo-generators, each served by a single boiler with a capacity of 830,000 lb of steam an hour.

THREADING MACHINES.—An addition to the "MB" series of threading machines made by Maiden and Co., Ltd., Cheshire, is the "Double-Four" machine, which has more heavily built headstock and is designed to thread bar up to 3in diameter in tough materials. It is driven by a 5 h.p. motor and has nine spindle speeds from 12½ to 104 r.p.m., the maximum saddle traverse being 39in. As in other machines in the series, die head release is automatic at the end of a predetermined threading length on the stock ; and the head can be closed either by a hand lever or automatically through the rearward movement of the saddle. The work is gripped by a self-centring vice fitted with interchangeable grips. Landis die heads are fitted as a standard on the machine, but other types can be used if required.

IRRADIATED POLYTHENE COAXIAL R.F. CABLES AND EQUIPMENT WIRES.—We learn that British Insulated Callender's Cables, Ltd., is manufacturing some types of small coaxial radio-frequency cables insulated with irradiated polythene. The polythene insulation is irradiated to reduce greatly deformation of the core during soldering, but otherwise these cables are of a standard construction. Although the power factor is slightly increased, other electrical characteristics are virtually unimpaired, and the cables are recommended for normal radio frequency applications at frequencies up to 200 Mc/s. In addition, irradiated polythene equipment wires with improved soldering properties are now available, together with a similar wire, which is also satisfactory for continuous operation up to 100 deg. Cent. The latter wire may also be operated at 120 deg. Cent. for 1500 hours and for shorter periods (approximately one hour) up to 250 deg. Cent., provided that care is taken to ensure that the insulation is not placed in contact with bare copper.

MR. RONALD BROWN.—We record with regret the death of Mr. Ronald Brown, the deputy chairman and managing director of Scotts' Shipbuilding and Engineering Company, Ltd., Greenock, which took place at his home Dornoch, Bridge of Weir, after a short illness on August 12. Mr. Brown, who was sixty-six years of age, served his apprenticeship with Scotts' and he returned to the company after service in the first world war and after gaining experience on Tyneside. He became engineering manager in 1941, director and general manager four years later and in 1950 was made deputy chairman and managing director.

W. R. OATEN.—A wide circle of engineers associated with railways in India during the past twenty-five years or so will hear with sincere regret of the death of Mr. W. R. Oaten on August 9 last at the age of sixty-six years. Mr. Oaten was educated at Eveswell School, Newport, Mon., and the Newport Technical School, and began his career at the Uskside Engineering Company, Ltd. In 1922 he went to the Newcastle on Tyne works of Armstrong Whitworth and Co., Ltd., where he eventually became progress engineer in the locomotive department. He began his association with the Indian railways in 1927, when he became assistant works manager at Golden Rock, Trichinopoly, of the South Indian Railways. In 1940 he became deputy chief mechanical engineer and six years later acting chief mechanical engineer. During the war years Mr. Oaten was closely concerned with the manufacture of munitions and aircraft components in India, and was awarded the O.B.E. for his services. After his retirement in 1947 he joined the staff of Sir Bruce White, Wolfe, Barry and Partners, and later in 1949 he became Assistant Editor (Mechanical) of our contemporary *Railway Gazette*.

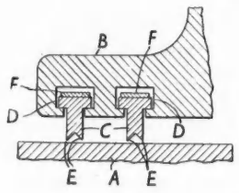
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

POWER TRANSMISSION

780,038. October 18, 1954.—Sealing Glands for Rotating Machines, Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 1–3, St. Paul's Churchyard, London, E.C.4. (*Inventors: Leonard Ellis Benson and Thomas Raine.*)

The invention is concerned with effecting gas sealing in steam turbines, gas turbines and generators. The invention comprises a labyrinth gas gland between relatively rotating parts in which one or both of the parts liable to rub against each other are of a sintered

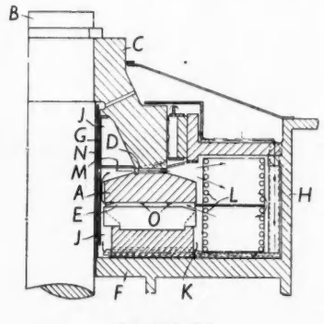


No. 780,038

metal. Sintered forms of iron should be satisfactory for gland materials operating temperatures up to 750 deg. to 850 deg. Fah., but for higher temperatures, where greater resistance to oxidation may be necessary, other sintered materials would be preferred—for example, sintered nickel containing graphite or sintered alloys such as nickel-chromium, nickel-cobalt, nickel-cobalt-chromium, or such alloys containing graphite. The drawing shows an example in which sealing is effected between a rotating shaft *A* and a stationary casing *B*, which may, for example, be the casing of a turbine. Gland segments of sintered metal *C* are supported in grooves *D* in the casing *B*. The gland segments are shown with sharp edges *E*. Leaf springs *F* hold the segments *C* downwards towards the shaft. With metals as used hitherto when rubbing occurs the metal melts and in the case, for example, of a gas turbine, this will allow escape of the hot gases and the heat may cause distortion of the shaft. A sintered metal, on the contrary, will wear sufficiently to avoid rubbing, but not sufficiently to cause escape of the gases.—*July* 31, 1957.

780,094. February 17, 1955.—Thrust Bearings, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: John Albert Herd.*)

The invention is concerned with the lubrication of thrust bearings, particularly those for large vertical shaft hydro-electric generators, or pump motors. As shown in the drawing, the rotating ring or runner *A* is fixed to the shaft *B* through a thrust collar *C*, and



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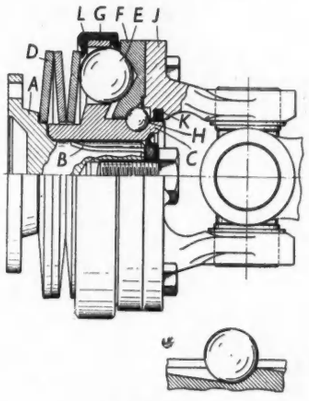
is provided with a number of radial oil ducts *D*. The thrust bearing surface consists of the area between the runner *A* and a stationary ring made up of a number of Michell pads *E* supported on the base *F* of the bearing housing. The oil reservoir is defined by the base *F*, an upstanding wall *G* closely surrounding the shaft *B*, and an outer wall *H*. It comprises an inner chamber *J* between the wall *G* and the bearing and an outer chamber *K* between the bearing and the wall *H* in which are housed the cooling coils *L*. A number of blades *M* constituting a radial impeller are mounted on a cylinder *N*. These blades are mounted above the plane of the bearing surface of the pads *E* and adjacent to the inner ends of the oil ducts *D*. The cylinder *N* extends downwards to the bottom of the inner oil chamber *J*. At their outer ends the oil ducts *D* are threaded to receive nozzles, by which the sizes of the orifices can be varied to suit differing operating conditions. The circulation of oil through the bearing is shown by arrows in the drawing. As the runner *A* rotates the oil will be drawn up by the centrifugal pumping action from the chamber *J* through the ducts *D* with the assistance of the blades *M*, and passes out through the nozzles into the chamber *K*. After passing through the cooling coils *L* it reaches the spaces between the pads *E* and lubricates the babbitted bearing surfaces *O*, the oil passing back to the chamber *J*.—*July* 31, 1957.

780,057. November 22, 1955.—Torque-Limiting Couplings, Kurt Schroter, 3A, Strassen, Herkenrath bei Bergisch-Gladback, Germany.

According to the invention there is provided a torque-limiting coupling with rollable drive bodies displaceable parallel to the axis of the coupling against spring pressure and serving for transmitting motion between two coupling members. The first



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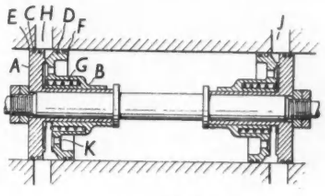
of the coupling members is constructed as the internal ring of an inclined bearing employing rollable bodies, on which bearing the second coupling member is rotatably carried and axially supported, and the drive bodies provide positive connection by engaging in depressions in part of one of the coupling members. As will be seen from the drawing, the adjustable projection *A* is formed by a flange projection on a splined shaft spigot *B* to which an internal part or hub *C* of the coupling is secured. The plate spring *D* presses spherical rolling drive bodies *E* into depressions in an annular plate *F*, and simultaneously holds the bodies in the guide bores in a flange projection *G* on the coupling hub *C*. The plate *F* forms the external ring of a ball bearing *H* and is bolted to an articulated fork *J*. The ball bearing *H* supports the plate *F* and hub *C* against all mutual axial and radial forces, and allows the plate and fork to be rotated as desired in relation to the hub. The ball bearing is externally closed by a seal *K*. An elastic oil-resisting protective cap *L* with two sealing lips is inserted between the peripheral edges of the plate spring *D* and the annular plate *F*, and surrounds the projection *G* and externally seals the balls *E*. The running track for the balls *E* diagrammatically illustrated in the lower view, is arranged concentrically with the axis of the shaft, and is provided with depressions. This ensures longer life for the annular plate *F*, because the balls have a large area of contact, and end pressure on the abutment is small. The running track can be so constructed that the balls have an abutment in one direction of movement only. This causes a freewheel action, which is very important for a number of agricultural machines with rapidly rotating parts. If, for example, a winch or drum in an agricultural machine is accelerated to high speed, and the speed of the driving shaft subsequently falls, very heavy stresses arise in the transmission members, and this is avoided by the construction of the track described.—*July* 31, 1957.

RAILWAY ENGINEERING

780,192. March 30, 1954.—Inside-Steam, Piston-Type Engine Slide Valves, Curt Garbe, Sen., 44, Fanningerstrasse, Berlin-Lichtenberg, Germany.

According to the invention there is provided an inside-steam piston slide valve, comprising at least two groups of piston rings on either head near the steam controlling edges. Each head carrying the piston rings consists of two separate components which are normally tightly held together under the pressure of the incoming steam, but which, on idling of the engine, are separated by a spring so that the ports of both cylinder end spaces are then put into communication with the slide valve steam chamber by apertures extending through each of the inner of the components. The drawing shows in the upper half the parts in position under steam pressure and in the lower half the parts relieved of steam pressure. The annular valve heads consist of the separate components *A* and *B*, each carrying groups of piston rings *C* and *D* near the steam controlling edges *E* and



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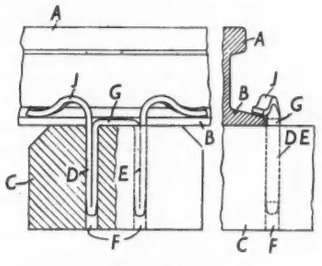
F on either side of the slide valve. When the steam enters the steam chamber the two components are tightly pressed together, as indicated in the upper portion of the drawing. The pressure of the steam acts on the annular area provided between the periphery of the inner piston-valve component *B* and the sealing surface between the piston valve components. With the steam shut off, i.e. when running idle, the two component parts *A* and *B*, by the interlocated spring *G*, are moved apart and the valve becomes as indicated in the lower portion of the drawing. The pressure equilibrium is now established across ports *H* and *J* for each end of the cylinder and across the apertures *K* of the inner component *B* with the slide valve steam chamber. The device has been designed with a view to securing a full pressure for holding the two component parts of the valve together even with a high rate of cut-off, by dimensioning the annular area sufficiently large. The spring *G* is strong enough to hold the body of the valve in neutral position when idling to avoid any knocking even at high speeds and in spite of forces exerted by the reciprocating masses. In the drawing the component parts *A* have annular sealing surfaces projecting from their inner surfaces with which co-operate sealing surfaces on the component parts *B*.—*July* 31, 1957.

779,534. November 11, 1954.—Resilient Rail Spikes, Erwin Wirsing, Parkstrasse 22, Schönberg, Tauns, Germany.

In the drawing, a rail *A* rests with its flange *B* on a sleeper *C*. The shanks *D* and *E* of a resilient rail spike are arranged directly adjacent the rail flange *B* in holes *F* in the sleeper *C*. The spikes are made by folding a metal strip so that the shanks are formed



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by a double thickness of the strip. At their upper ends, the shanks *D* and *E* are connected by a common web or arm *G* which extends parallel to the rail and serves as an abutment for the rail flange *B* and also limits the penetration of the shanks into the sleeper. The web *G* rests on the upper surface of the sleeper *C*, when the spike is fully inserted, the spike being then correctly stressed. The securing of the rail to the sleeper is effected by the ends of the strip, each of which forms a curved spring portion at the upper end of a shank, these portions *J* engaging obliquely over the rail flange. Other designs are also shown in the specification.—*July* 24, 1957.

BLOWERS AND COMPRESSORS

780,463. November 21, 1955.—Multi-Stage Centrifugal Compressors, Sulzer Frères, Société Anonyme, Winterthur, Switzerland.

In a multi-stage centrifugal compressor according to the invention, in at least a part of the series of stages the leading runners are made of a material the heat resistance of which is less than that of the material of which the succeeding runners are made. The invention is of particular value where a high pressure ratio is achieved by the compressor and high temperatures are thus produced in the later stages. In one form the leading runners are made of an alloy containing predominantly aluminium and the succeeding runners of grey cast iron of a tensile strength of

20 kg to 100 kg per square millimetre. In another form the leading runners may be made of a copper-aluminium alloy and the succeeding runners of grey cast iron with an addition of nickel, whilst in a third form the leading runners may be made of a silicon-aluminium alloy, and the succeeding runners of cast steel or fabricated steel plate. A drawing accompanying the specification (not reproduced herewith) shows by way of example a longitudinal section of a six-stage centrifugal compressor. The runners of the four leading stages are made of a silicon-aluminium alloy, and those of the succeeding stages of grey cast iron with an addition of nickel. When used for sucking water in paper-making machines this particular compressor produces a pressure ratio by which a temperature of over 100 deg. Cent. is experienced in the two final stages, whereas the temperature in the leading stages remains below that value.—*July* 31, 1957.

Technical Reports

Microdébitmètre à Perte de Charge D.F.G. By F. Debeauvais, R. Feidt and C. Gebel. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T. 64. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte d'Issy, Paris (15e). Price Fr. 400.—The study describes a novel design of flow-meter covering a range of up to a few cubic centimetres per second. The instrument uses the pressure loss in a long capillary, under conditions of laminar flow, applying the corrections required for obtaining absolute measurements of great precision.

Recherches Théoriques et Expérimentales sur Les Mouvements des Liquides Pesants Avec Surface Libre. By A. S. Apté. Publications Scientifiques et Techniques du Ministère de l'Air, No. 333. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Fr. 1450.—The first part of the report deals with the limiting case of a single wave. Using conformal representation, an approximate solution is developed, which is shown to involve but a small error, better than that of the classical McCowan formulæ and sufficient for all applications. In the second section the author analyses in detail the kinematics of the three-link wave generator. Applying the linear theory of Havelock-Biésel, he calculates amplitude and phase of successive harmonics of the fundamental wave. In the last section, which is the most important one, the recent results of McNown regarding linear sinusoidal oscillation of the free surface, are extended. Agreement with experiment is shown to be good.

La Rénovation de la Soufflerie S3 du Service Technique Aéronautique. By R. Lecardonne. Appendix: *Calcul Aérodynamique d'une Hélice Ventilateur.* By M. Gruzon. Publications Scientifiques et Techniques du Ministère de l'Air, No. B.S.T. 119. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Fr. 1300.—At the time of its being put into service in 1920. the "S3" wind tunnel of the Service Technique Aéronautique of the French Air Ministry had been one of the largest and fastest in the world. Built entirely of reinforced concrete, it was equipped with a 1000 h.p. fan, which was able to generate an air speed of 80m per second in the 3m diameter test section. After the defeat of 1940, all the equipment was removed by the Germans and only the shell remained. Because of its robust structure and its central situation, it was decided after the war to put it back into commission. In 1946 it was completely re-equipped with a 500 h.p. motor, giving it a speed of 60m per second in the test section. After 1951 it was modernised, brought up to 2000 h.p., and improved aerodynamically. The present monograph describes those developments.

Measurements of the Thrust Produced by Convergent-Divergent Nozzles at Pressure Ratios up to 20. P. F. Ashwood, G. W. Crosse and Jean E. Goddard. A.R.C. Current Paper No. 326., H.M. Stationery Office. Price 3s. 6d.—In continuation of a previous investigation, tests have been made on a series of convergent-divergent nozzles having an included divergence angle of 20 deg. to obtain performance data at pressure ratios applicable to jet engines operating in the flight speed range $M=2$ to $M=3$.

A new test technique has been used which, by utilizing the ejector action of the jet from the test nozzle to reduce the exit pressure, enables the range of pressure ratios obtainable across the nozzle to be extended threefold. This technique, which has proved simple to apply and control, is described in detail.

The tests have shown that, as would be expected, the maximum thrust coefficient falls slightly with increasing design pressure ratio, the decrease amounting to about 1·2 per cent as between nozzles designed for pressure ratios of 10 and 25. This is shown to be in reasonable agreement with the calculated skin friction loss.

An empirical formula has been deduced for predicting the kink point, that is the lowest pressure ratio at which the shock system lies wholly beyond the nozzle exit plane. This formula supersedes that given in the report of the earlier tests which was based on a limited range of design and test pressure ratios and which could not confidently be extrapolated beyond the test limits.

An Empirical Analysis of the Planing Lift Characteristics of Rectangular Flat Plates and Wedges. P. Ward Brown, B.Sc., of Short Brothers and Harland, Ltd. Reports and Memoranda No. 2998. H.M. Stationery Office. Price 7s.—The fluid flow about planing plates and wedges is briefly described and discussed, and on the basis of theoretical and physical considerations of this flow empirical formulæ are presented for the lift developed by these planing surfaces. The formulæ are mutually compatible and cover the whole range of planing of zero and finite deadrise surfaces including the chine-dry and chine-wet conditions. The lift formulæ are extensively compared with experimental data, over a range of trim angles from 2 deg. to 30 deg. and deadrise angles from 0 deg. to 40 deg., and very good agreement obtained.

The analysis confirms the existence of an effective critical wetted length for all the planing surfaces studied and shows that the wave-rise about planing wedges is an irrelevant feature of the flow.

The formulæ are thought to be of such a nature that they may form the foundation for the lift prediction of more complex planing surfaces than are dealt with here.

Launches and Trial Trips

R.M.S. DARWIN, cargo-passenger ship; built by the Goole Shipbuilding and Repairing Company, Ltd., for the Falkland Islands Company, Ltd.; length between perpendiculars 220ft, breadth 40ft, depth moulded 17ft 6in, deadweight 1090 tons, speed 12 knots; 36 passengers; triple-expansion machinery, cylinder diameters 17in, 27½in and 45in by 30in stroke, steam supplied at 200 lb per square inch by two boilers. Trial, June 14.

DULWICH, raised quarter deck collier; built by Hall, Russell and Co., Ltd., for the South Eastern Gas Board; length between perpendiculars 261ft 6in, breadth moulded 39ft 4in, depth moulded 18ft 6in, deadweight 2835 tons; three holds, electric deck machinery; British Polar diesel engine, eight cylinders, 1150 b.h.p. at 225 r.p.m. Launch, June 24.

KING CHARLES, cargo ship; built at Belfast by Harland and Wolff, Ltd., for the King Line, Ltd.; length overall 467ft, length between perpendiculars 435ft, breadth moulded 59ft, depth moulded to shelter deck 39ft 9in, deadweight 9500 tons; two complete steel decks, four main cargo holds, one 50-ton, one 25-ton, four 10-ton, and six 5-ton derricks, electric winches; three 125kW diesel-driven generators; Harland and Wolff - B. and W. single-acting, four-stroke diesel engine, six cylinders, 740mm diameter by 1500mm stroke, 115 r.p.m. Trial, June 25.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ENGINEERING, MARINE, WELDING AND NUCLEAR ENERGY EXHIBITION

Thurs. to Thurs., Aug. 29 *to Sept.* 12.—Olympia, Hammersmith Road, London, W.14, open daily 10 a.m. to 6 p.m., Fridays 10 a.m. to 8 p.m.

ENGINEERS' GUILD

Fri., Sept. 20.—S. WALES AND MONMOUTHSHIRE BRANCH: Old Arcade Inn, Church Street, Cardiff, Luncheon, 12.45 p.m.

Thurs., Sept. 26.—METROPOLITAN BRANCH: Caxton Hall, Caxton Street, Westminster, London, S.W.1, Annual General Meeting, Discussion on "The Aims and Future Policy of the Guild," 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Sept. 3.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "Maximum Demand and Power Factor and their Effect on the Electricity Tariff," T. A. Williams, 7 p.m. ★ EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, Members' Evening, 7 p.m.

Wed., Sept. 4.—LEICESTER BRANCH: Bell Hotel, Leicester, "The Painting of Buildings," R. Woodwards, 7 p.m.

Mon., Sept. 9.—DUNDEE BRANCH: Mathers Hotel, Dundee "Variable-Speed Drives with Voltage Regulation Equipment," 7.30 p.m. ★ MERSEYSIDE AND N. WALES BRANCH: The Blossoms, City Road, Chester, "The Cost Accountant and the Plant Engineer," R. G. Hall and B. J. Willson, 7.15 p.m.

Tues., Sept. 10.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, Chairman's "At Home," 7.15 p.m.

Wed., Sept. 11.—W. BRANCH: Grand Hotel, Bristol, "Fire Prevention in Industrial Buildings," 7.15 p.m.

Thurs., Sept. 12.—GLASGOW BRANCH: Scottish Building Centre, Glasgow, "The Design and Application of Rotary and Reciprocating Air Compressors," W. Scott, 7.15 p.m. ★ N.E. BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Internal Combustion Engines as Applicable to Plant Engineering," Norman Parry, 7 p.m.

Tues., Sept. 17.—BIRMINGHAM BRANCH: Hotel Leofric, Coventry, "Titanium as a Material of Construction in the Chemical Industry," K. W. J. Bowen, 7.30 p.m.

Wed., Sept. 18.—KENT BRANCH: King's Head Hotel, High Street, Rochester, Ladies' Film Evening, 7 p.m.

Thurs., Sept. 19.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, Joint Meeting with Institute of Fuel, "Fuel and Power Position in the United Kingdom," Rear-Admiral Sir Sidney Frew, 7.30 p.m.

Tues., Sept. 24.—GLASGOW BRANCH: Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, Joint Meeting with the Institution of Heating and Ventilating Engineers, "Steam," and "Combustion and the Chain Grate Stoker," 7.15 p.m. ★ S. WALES BRANCH: South Wales Engineers' Institute, Park Place, Cardiff, "Metal Degreasing by Trichloroethylene," and "Metal Pretreatment in Industry," 7.15 p.m.

Thurs., Sept. 26.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "The Design of Rolling Mills, with particular reference to Hot and Cold Ferrous Mills," M. Langen, 7.30 p.m.

Fri., Sept. 27.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Some Principles of Radiant Heating," P. A. Coles, 7.30 p.m.

Mon., Sept. 30.—W. AND E. YORKSHIRE BRANCH: Leeds University, "The Safe Use of Electricity," J. J. Emerson, 7.30 p.m.

INSTITUTE OF FUEL

Wed., Oct. 9.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Symposium on "Flames and Industry," 10 a.m.

INSTITUTE OF METALS

Mon. to Fri., Sept. 16 *to* 20.—Forty-ninth Annual Autumn Meeting, 1957, to be held in Glasgow.

INSTITUTE OF THE MOTOR INDUSTRY

Sat. to Sat., Aug. 24 *to* 31.—St. Catharine's College, Cambridge, Eleventh Annual Summer School.

INSTITUTE OF PETROLEUM

Wed., Sept. 4.—26, Portland Place, London, W.1, "Some Developments in Marine Drilling Foundations," A. Kranendonk, 5.30 p.m.

INSTITUTE OF PHYSICS

Tues. to Thurs., Sept. 10 *to* 12.—ELECTRON MICROSCOPY GROUP: University College of North Wales, Bangor, Annual Coaference.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Sept. 9.—N.E. BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, Chairman's Address, Informal Discussion on Branch Affairs, 7.15 p.m.

Mon., Oct. 14.—N.E. BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Building Structures," G. Gladstone, 7.15 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., Aug. 31.—S. BRANCH: Whole-day visit to the pumping stations of the Mid-Wessex Water Company, Frimley, Surrey.

Sat., Sept. 14.—SOUTHERN BRANCH: Whole-day visit to the Greenham Common Base of the United States Air Force, Newbury, Berks, 10 a.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Sept. 4.—COVENTRY GRADUATE SECTION: Visit to British Piston Ring Company, "Changing from Batch to Flow Production," H. C. Blackford, 7.15 p.m.

Wed., Sept. 18.—BIRMINGHAM SECTION: College of Technology, Gosta Green, Birmingham, 4, Film Evening, 7 p.m. ★ WOLVERHAMPTON GRADUATE SECTION: Wolverhampton and Staffs College of Technology, Wulfruna Street, Wolverhampton, "Nimonic Presswork," J. A. Grainger, 7.30 p.m.

Tues., Sept. 24.—OXFORD SECTION: Town Hall, Oxford, "Transfer Pressing," 7.30 p.m.

Wed., Sept. 25.—SHREWSBURY SECTION: Shrewsbury Technical College, Shrewsbury, "British Clock and Watch Production," R. Lenoir, 7.30 p.m.

Thurs., Sept. 26.—NORWICH SECTION: Norwich City College, Ipswich Road, Norwich, "S.G. Iron—A Versatile Engineering Metal," W. W. Braidwood, 7 p.m.

Fri., Sept. 27.—LEICESTER SECTION: Grand Hotel, Leicester, "Work Measurement and Its Uses for Management," W. Hewett, 7 p.m.

Fri., Oct. 4.—Dorchester Hotel, Park Lane, London, W.1, Annual Dinner.

IRON AND STEEL INSTITUTE

Wed. and Thurs., Sept. 25 *and* 26.—IRON AND STEEL ENGINEERS' GROUP: Church House, Westminster, London, S.W.1, "Air Pollution in the Iron and Steel Industry."

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., Oct. 10.—Mining and Technical College, Wigan, Annual General Meeting, 3.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Fri., Sept. 13.—FORTY-FIFTH WILBUR WRIGHT MEMORIAL LECTURE: Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Advanced Education and Academic Research in Aeronautics," Clark B. Millikan, 6 p.m.

SOCIETY FOR WATER TREATMENT AND EXAMINATION

Wed. to Fri., Oct. 2 *to* 4.—Palace Hotel, Southend-on-Sea, Autumn Meeting.

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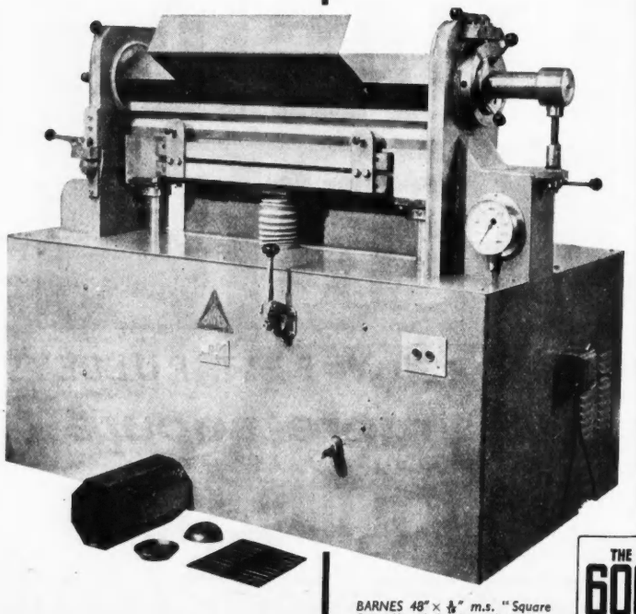

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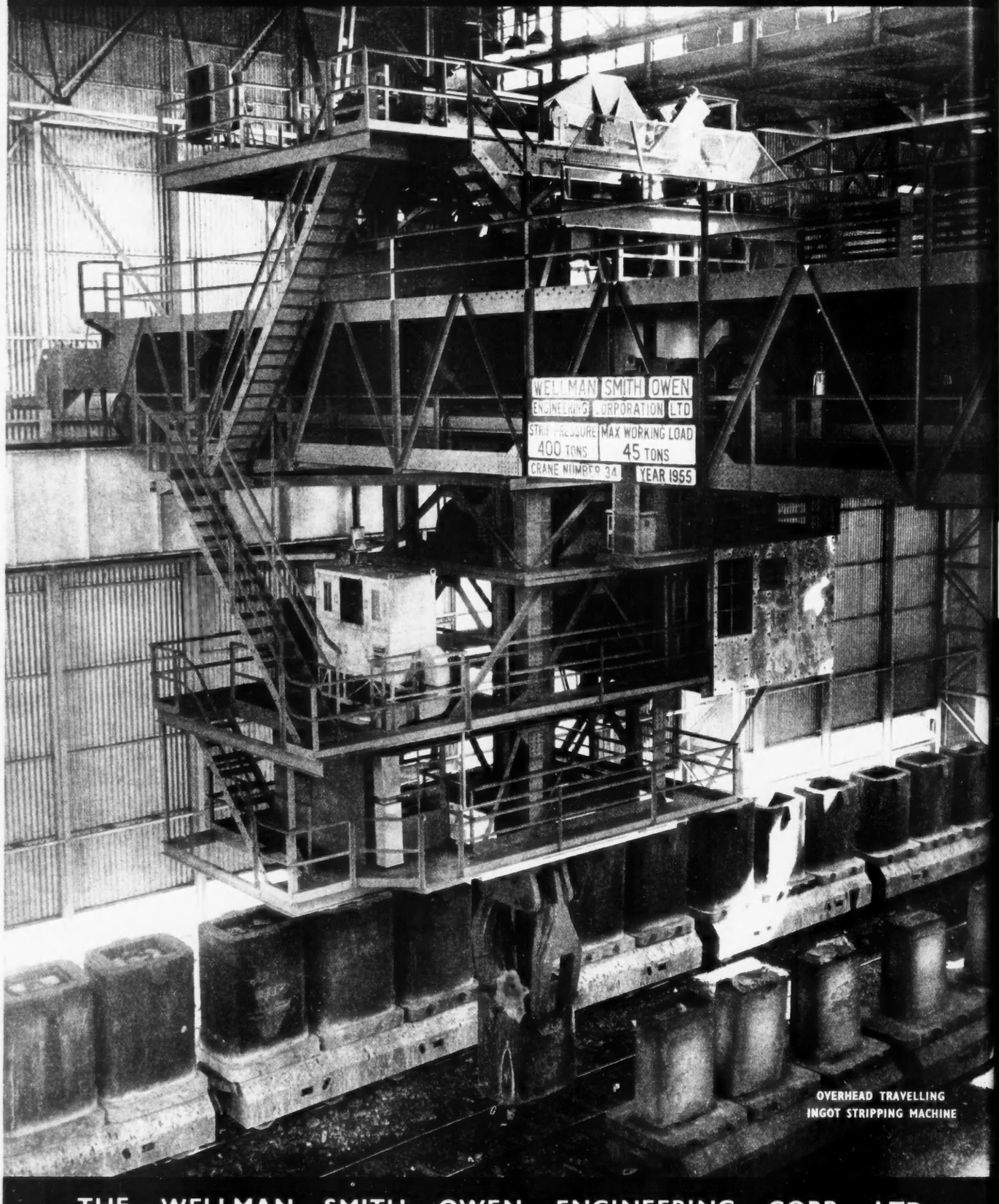

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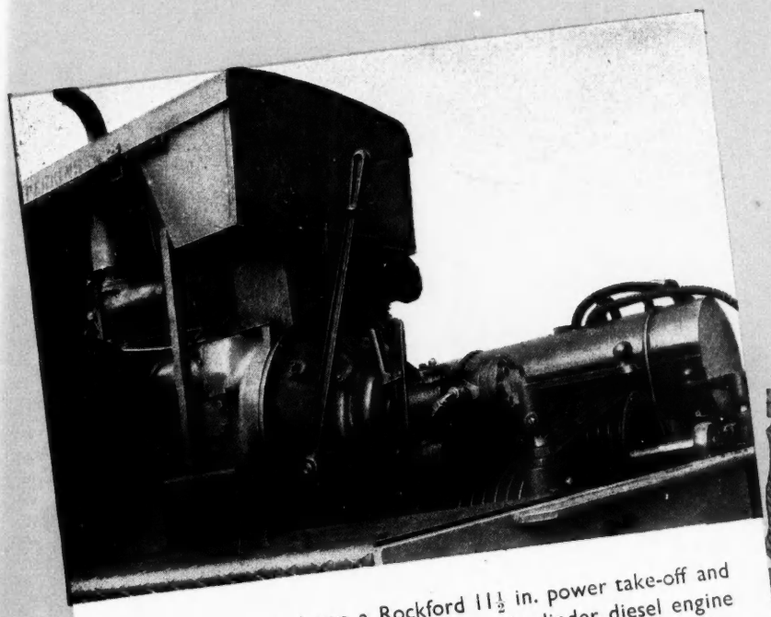
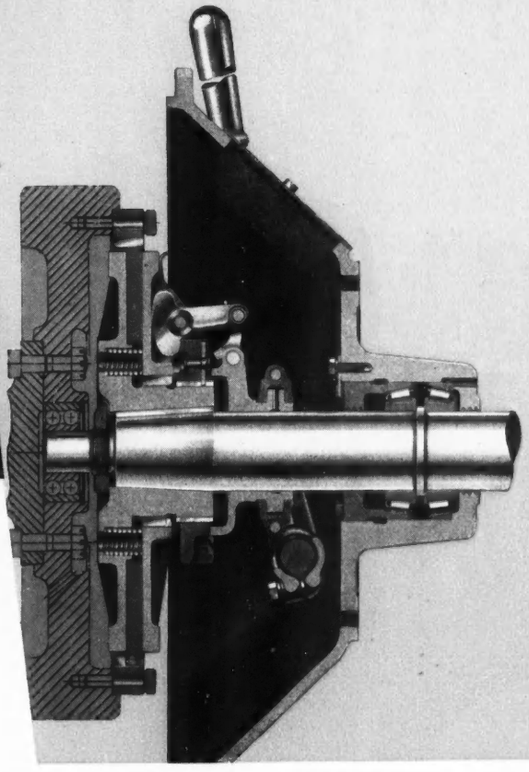


This illustration shows a Rockford 11½ in. power take-off and 'over-centre' clutch unit on a Perkins 4-cylinder diesel engine on the Blaw Knox PF-90 Bituminous Paver Finisher. This interesting machine can lay pavement in any width from 8 ft. to 13 ft.
At right, a typical Rockford power-take-off unit.



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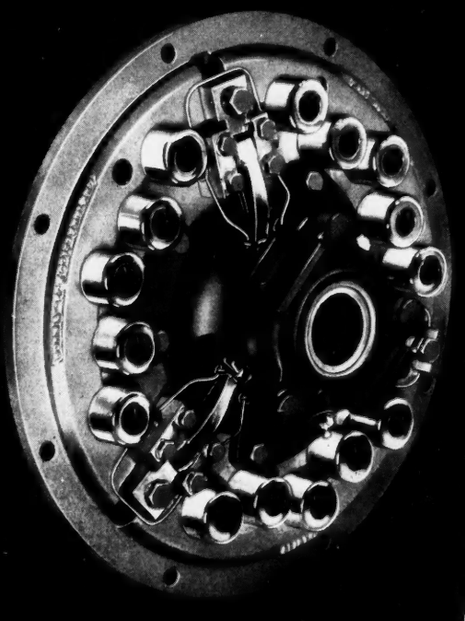

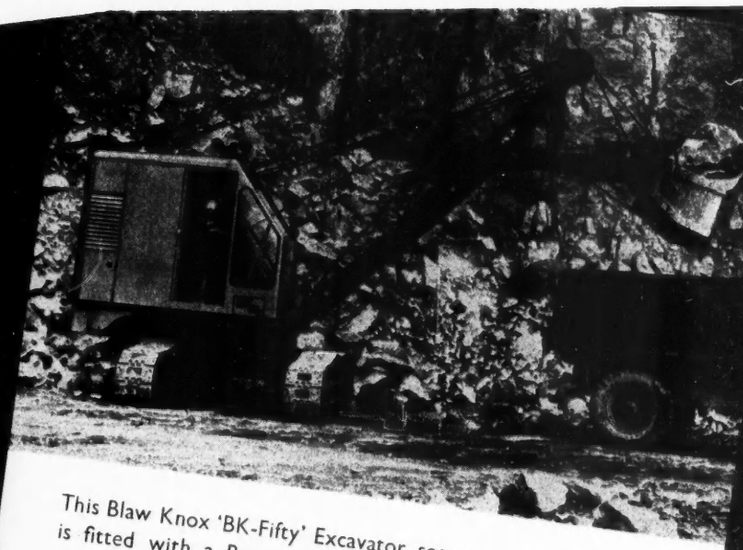

This Blaw Knox 'BK-Fifty' Excavator, seen at work in a quarry, is fitted with a Borg & Beck 14-inch clutch. Borg & Beck clutches are used on the majority of Britain's commercial vehicles. A recent addition is the Borg & Beck combined clutch and power take-off.

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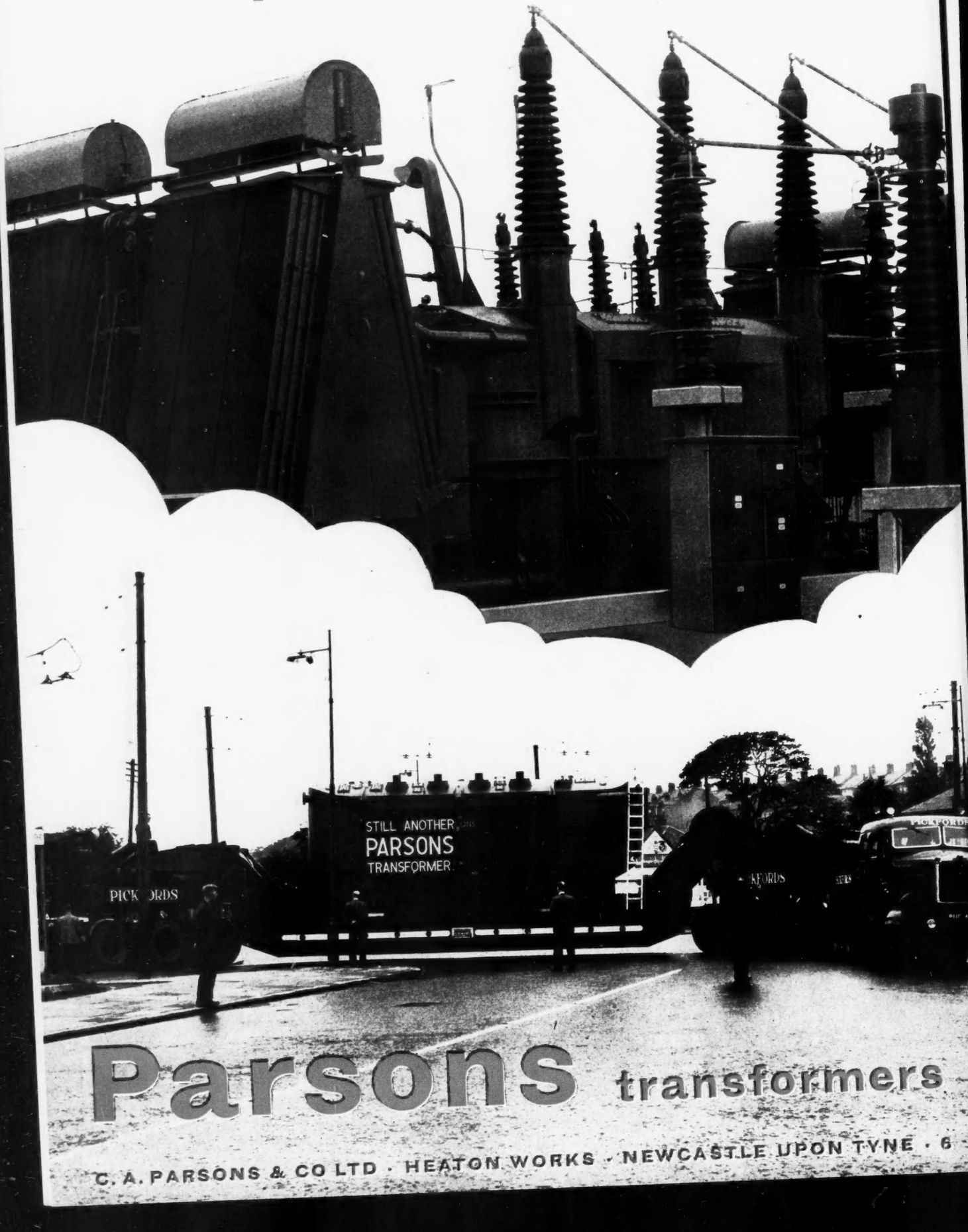

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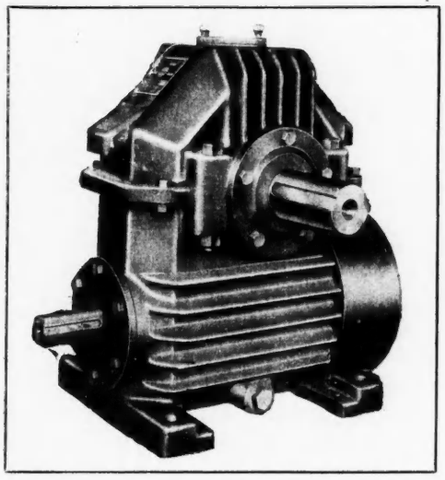

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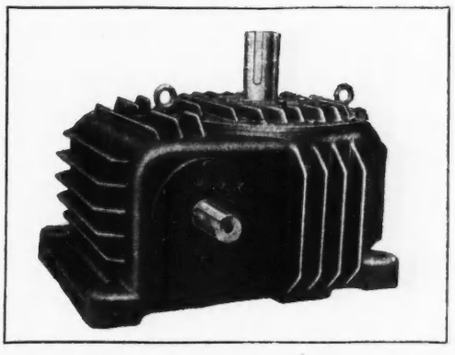

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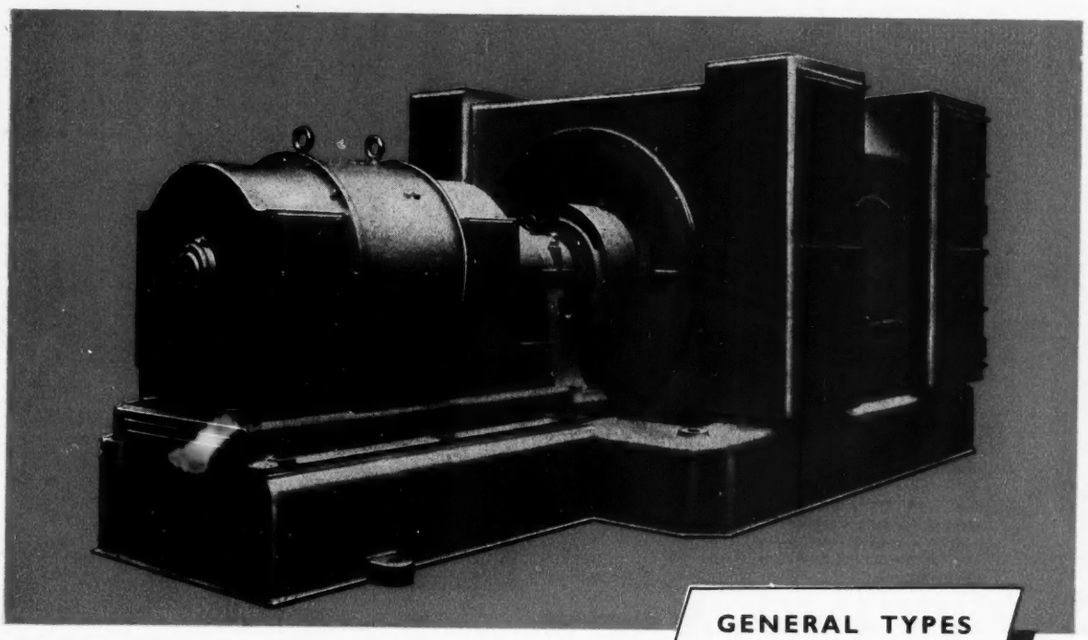

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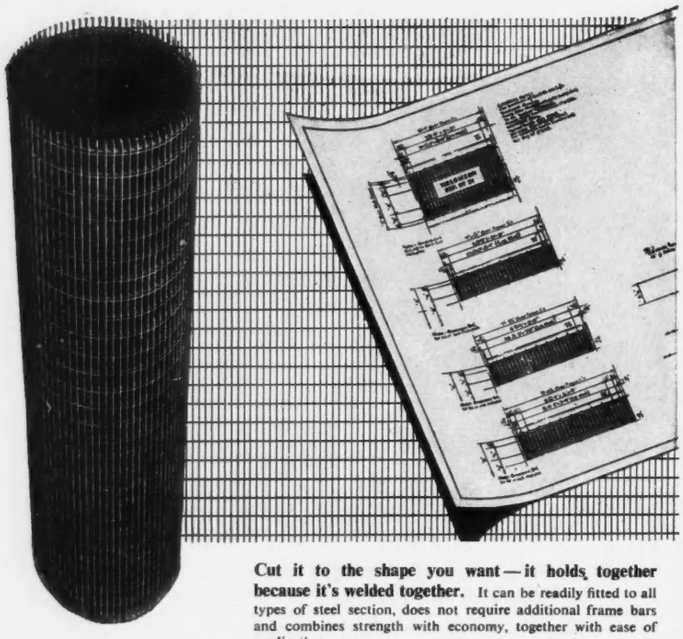

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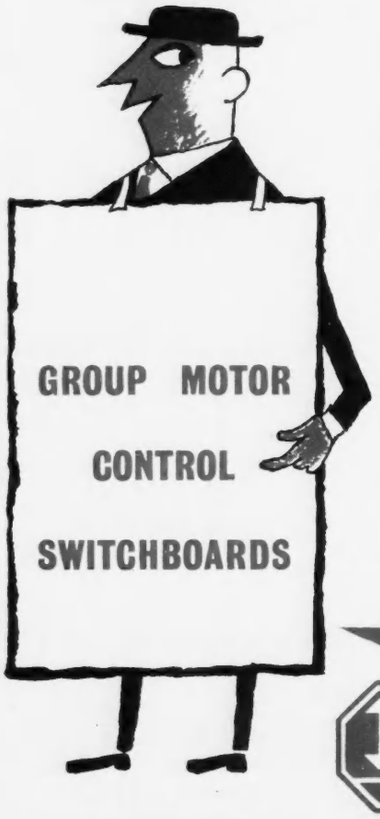

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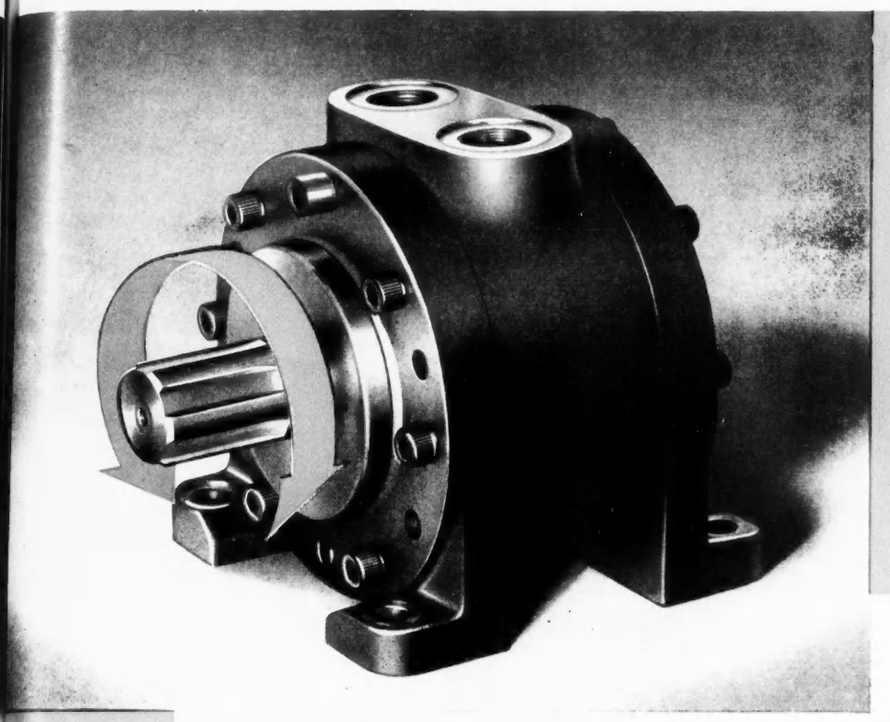

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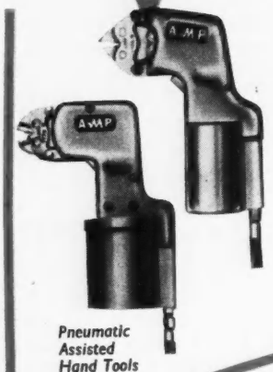

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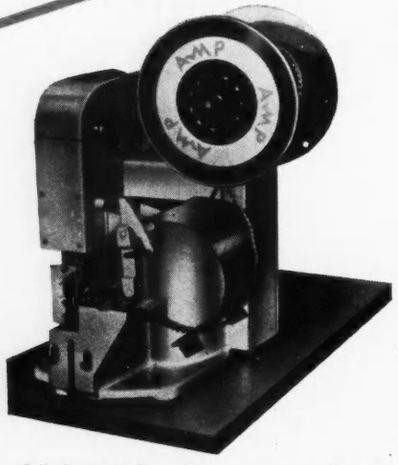

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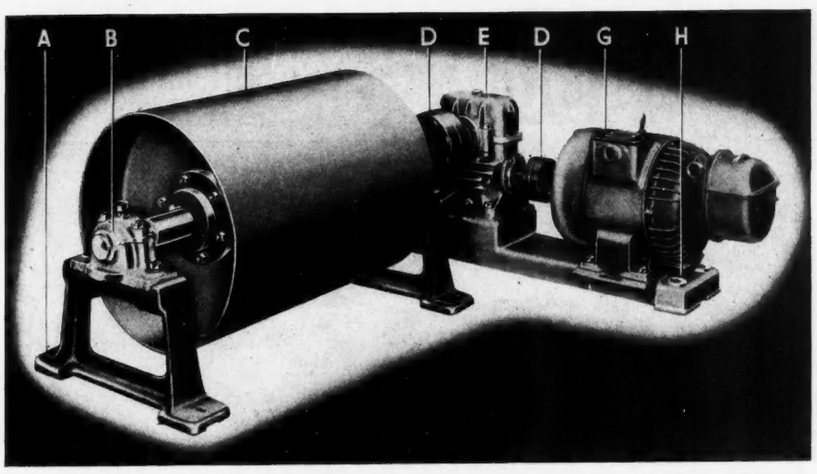

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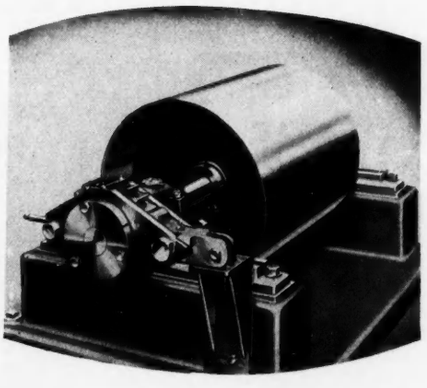

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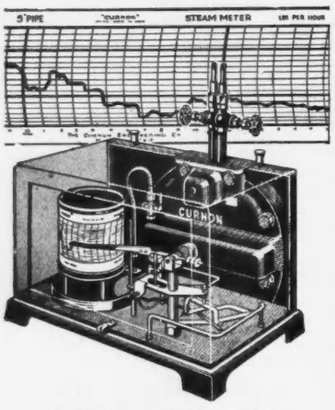

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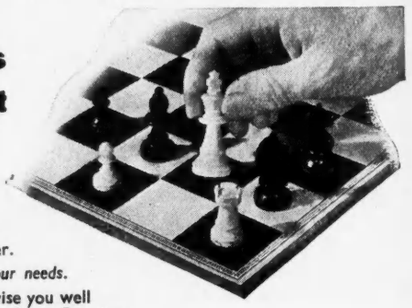

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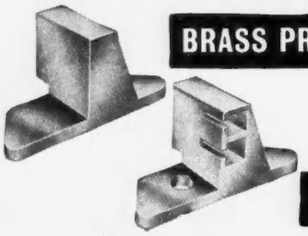

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If requested, our technical representatives will be pleased to advise you without obligation.

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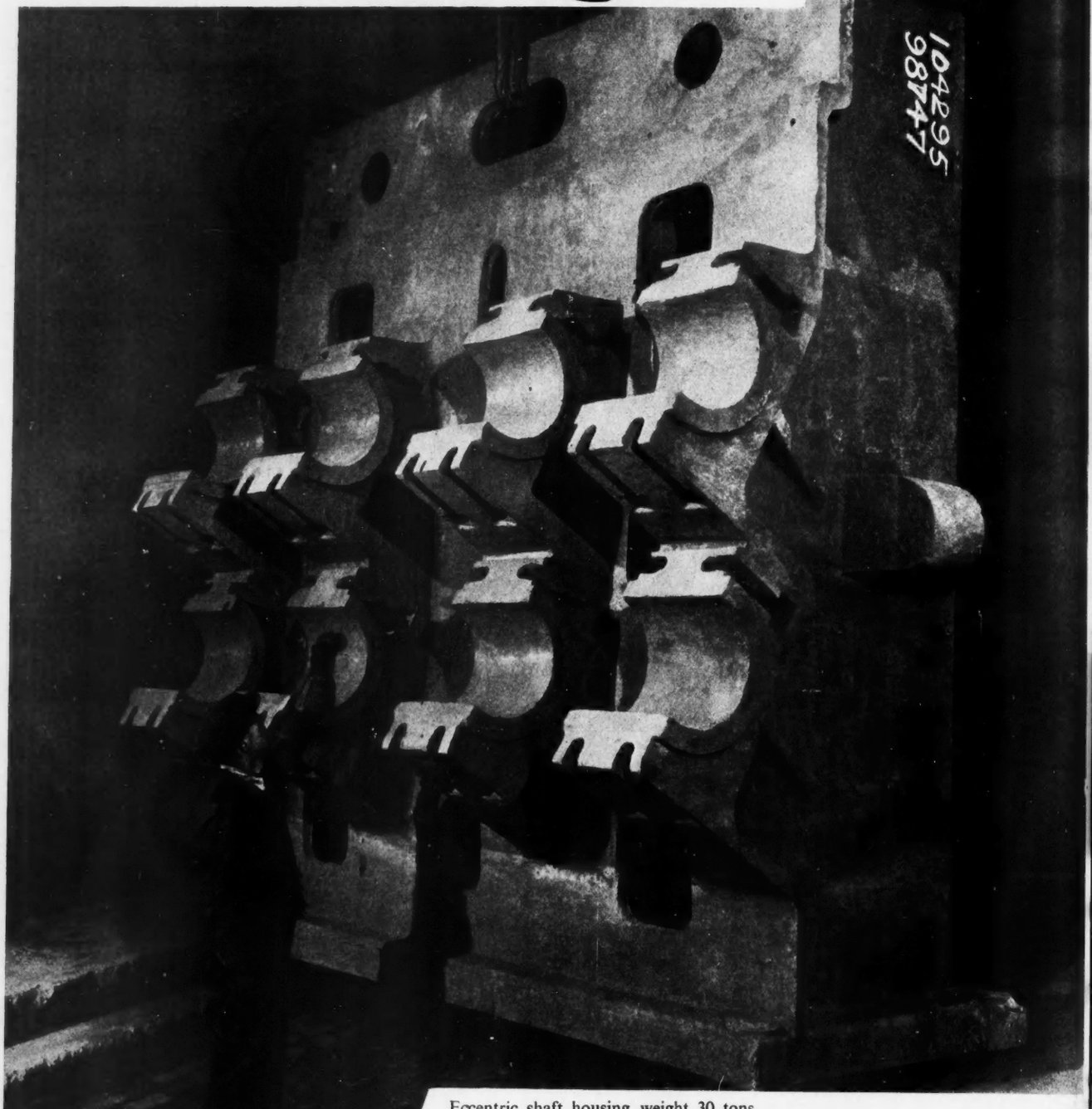

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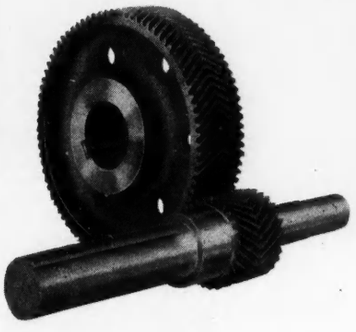

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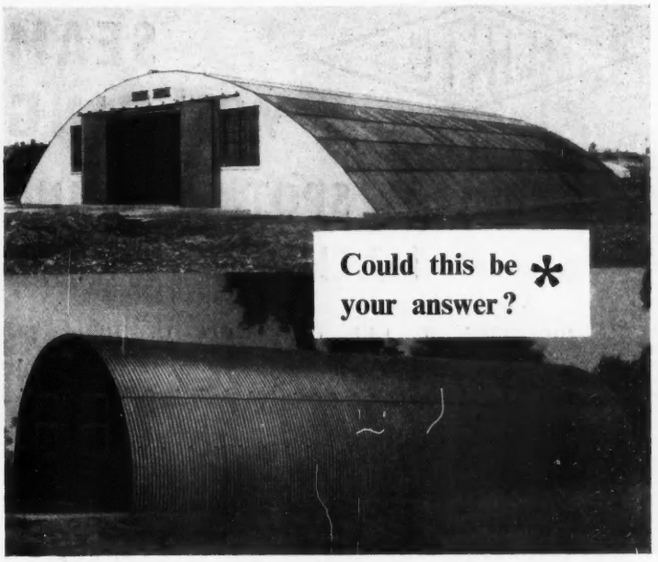

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The bottom photograph is of a Nissen-type Hut, size 48′ × 16′, at Langley Park Golf Club.

Basic widths available—16ft., 24ft., 30ft., 35ft., 91ft.

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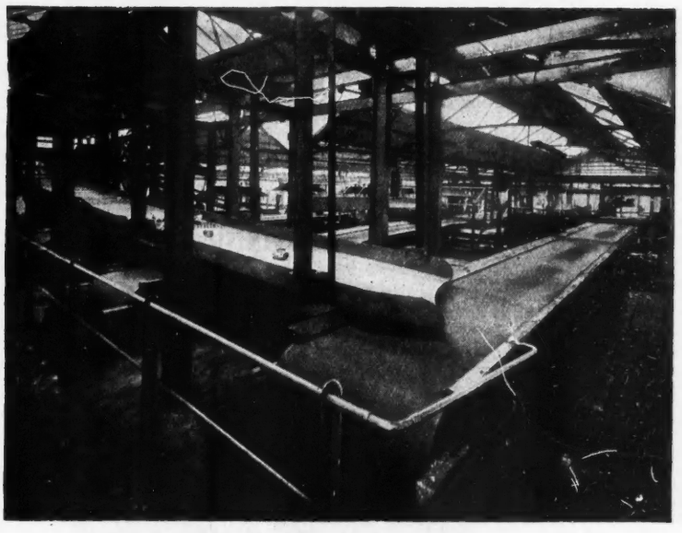

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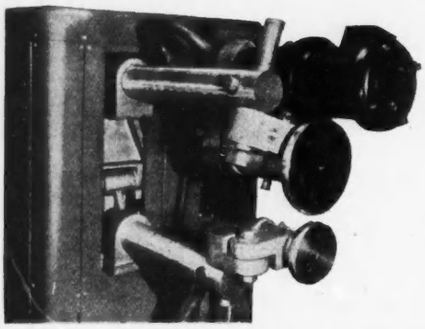

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Stout Cortes gazing on the Pacific has nothing on the man who first experiences G.G.L. service and quality. Trouble is, he tends to go on and on regardless, and when you get carried away, anything can happen. Still, we don't suppose you will blame him if you have ever tried G.G.L. yourself.

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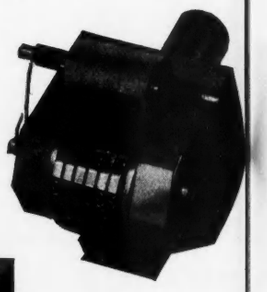

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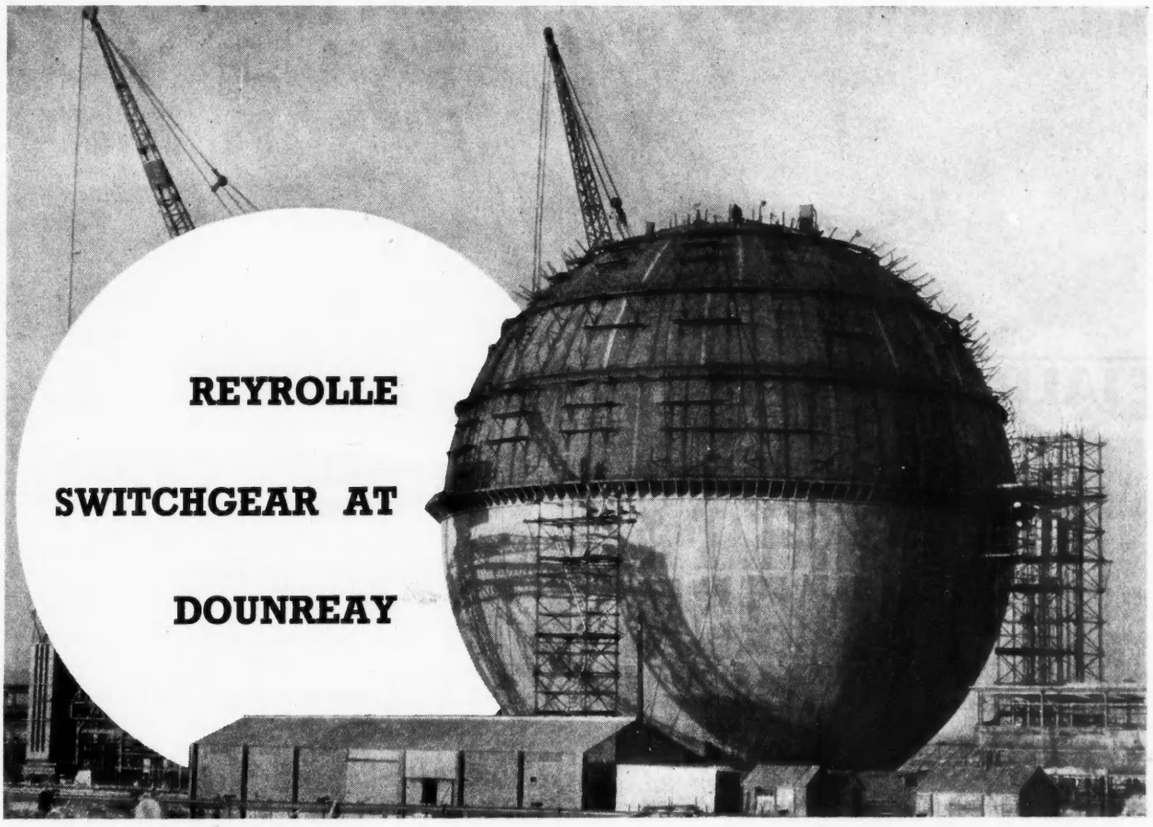
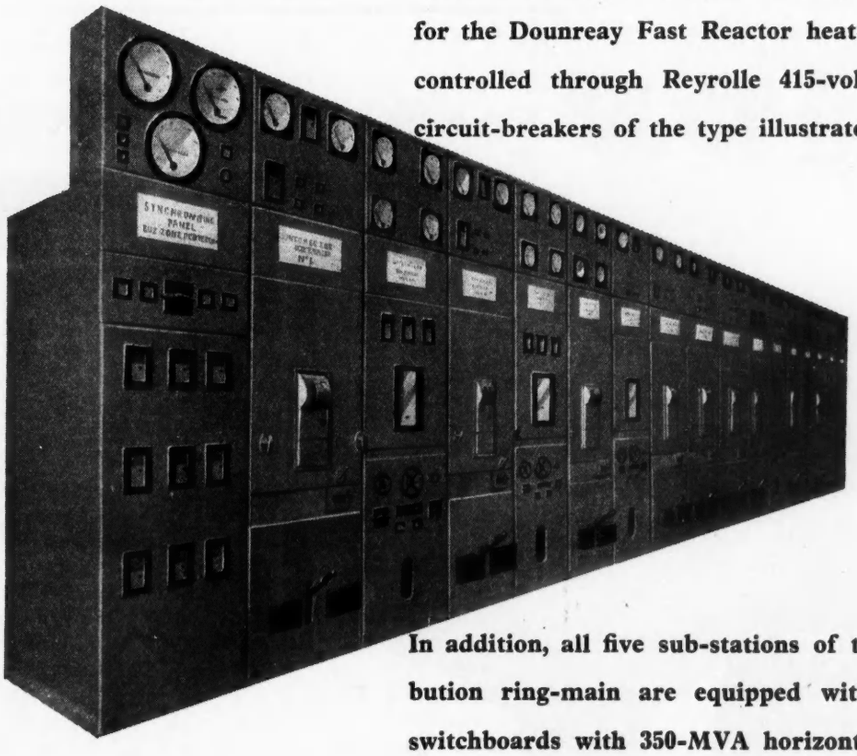


REYROLLE SWITCHGEAR AT DOUNREAY

Photograph by courtesy of the U.K.A.E.A

The electro-magnetic liquid-metal pumps and other services for the Dounreay Fast Reactor heat-exchanger system are controlled through Reyrolle 415-volt 31·5-MVA air-break circuit-breakers of the type illustrated.



17-panel switchboard comprising Reyrolle type-S22A air-break circuit-breakers with associated control cubicles.

In addition, all five sub-stations of the main 11-kV distribution ring-main are equipped with Reyrolle metalclad switchboards with 350-MVA horizontal draw-out oil-break circuit-breakers.

Reyrolle

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The moderate cost of METALRAX Gravity ROLLER CONVEYORS is very soon repaid in time gained and labour saved. The wide use of these better-made conveyors by important organisations everywhere is proof of efficiency. Send for current list which gives full details of sizes and prices, straight sections, standard bends and adjustable stands.

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EFFECTIVELY SEAL THREE FACES

Eliminate by-pass, Restore compression, Maintain full power, Function until bore of cylinder is worn by as much as 1%.

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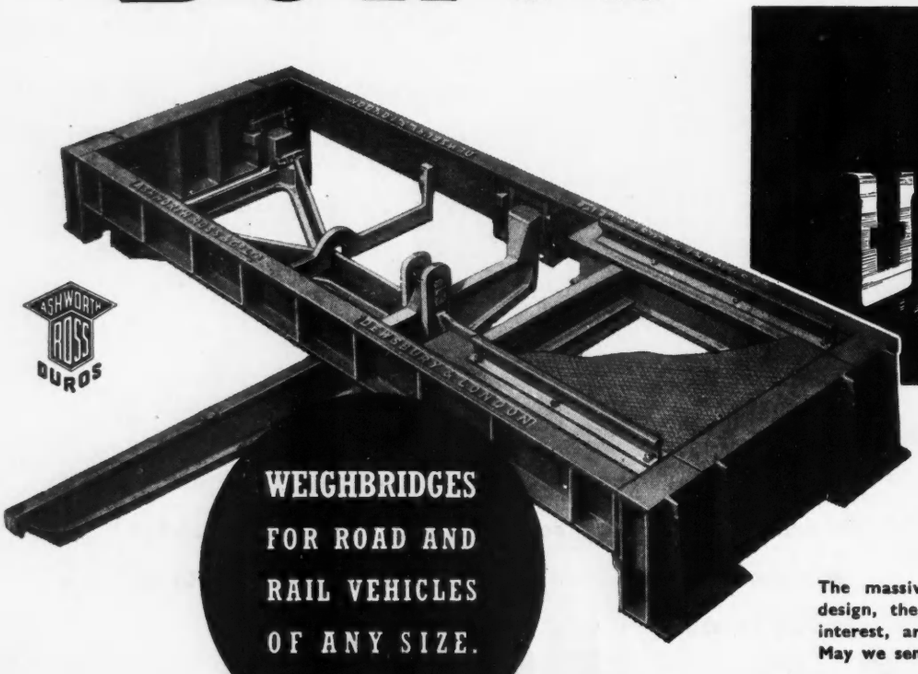
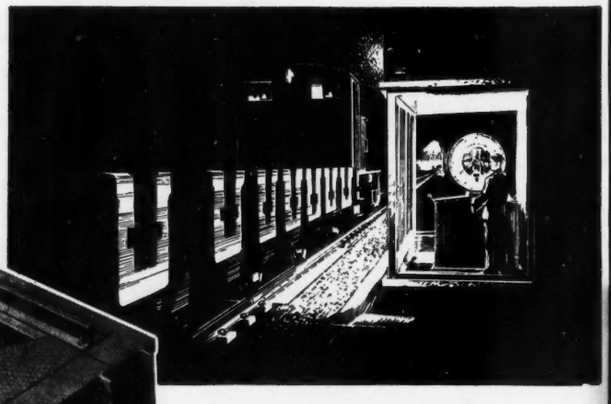
a DUROS with the 'lid' off





THIS SECTIONAL VIEW OF A TYPICAL 'DUROS' WEIGHBRIDGE REVEALS THE REASON FOR OUR HIGH REPUTATION.

WEIGHBRIDGES FOR ROAD AND RAIL VEHICLES OF ANY SIZE.

The massive construction of frame and levers, the clean design, the adjustable knife edges, with other points of interest, are illustrated clearly in our current brochure. May we send you one ?

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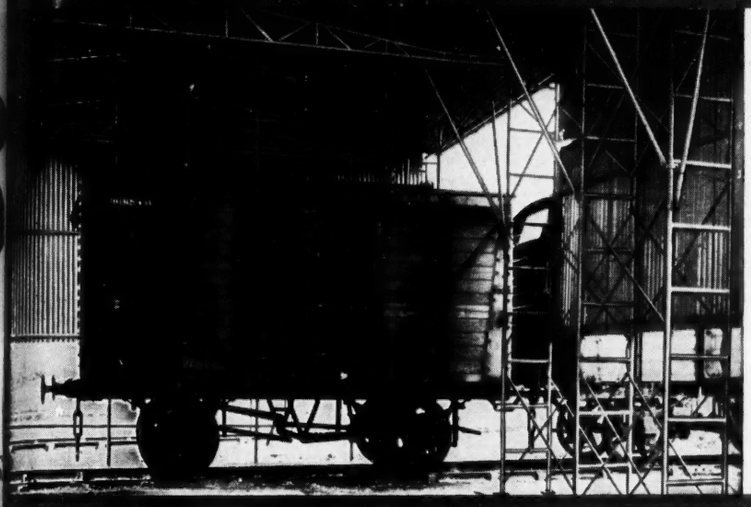
STERLING SAFWAY UNIT FRAME CONSTRUCTION

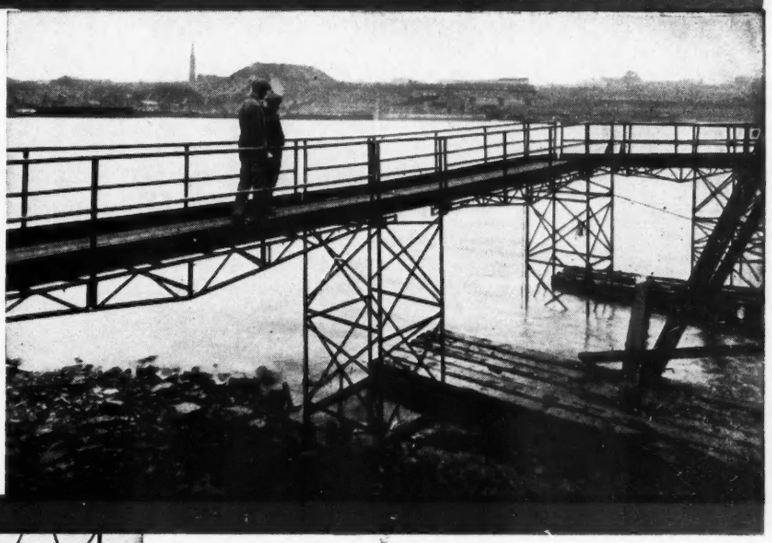
for all industrial purposes



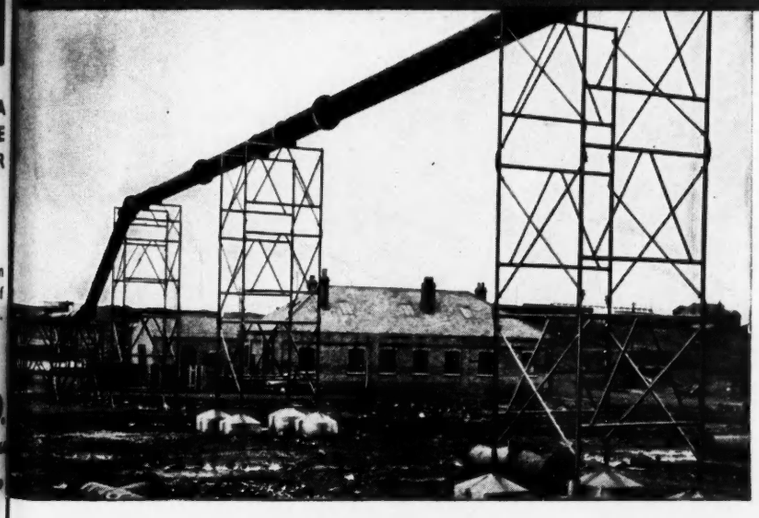
Versatility in application is one of the outstanding characteristics of Sterling Safway Unit Frame Scaffolding. These pre-fabricated unit frames have been successfully employed in an astonishing diversity of ways — a few of which are shown in this advertisement, but other unusual uses include ski-run towers, wind tunnels, movable rock drilling stages etc. No other form of scaffolding is so adaptable or so easy to assemble.

On left: Rail canopy in use at Lever Bros.

However, it is not merely for the unusual job that Sterling Safway stands pre-eminent. For every normal use in building and constructional work, large or small; for maintenance and decoration inside or outside; for ships' stages and all engineering and industrial uses, Sterling Safway Unit Frame Scaffolding is supreme — because half the work is done before it reaches the site, which saves time, money and labour.



On right: Cross Berth Gangway at Messrs. Swan Hunter and Wigham Richardson, Neptune Yard, Walker-on-Tyne.



Sterling

SAFWAY UNIT FRAME

STERLING FOUNDRY SPECIALITIES LIMITED

JARROW	LONDON	EDINBURGH	BEDFORD
Sterling Factory, Jarrow, Co. Durham. Tel: Jarrow 89-7721/2/3	Iddesleigh House, Caxton Street, London, S.W.1. Tel: Abbey 3017/8 (2 lines)	23, Rutland Square, Edinburgh, 1. Tel: Fountainbridge 3254/5	Sterling Works, Bedford. Tel: Bedford 5338 (3 lines)

GLASGOW	BRISTOL
28, Renfield Lane, Glasgow, C2. Tel: City 6201/2	175, White Ladies Road, Bristol, 8. Tel: Bristol 39112

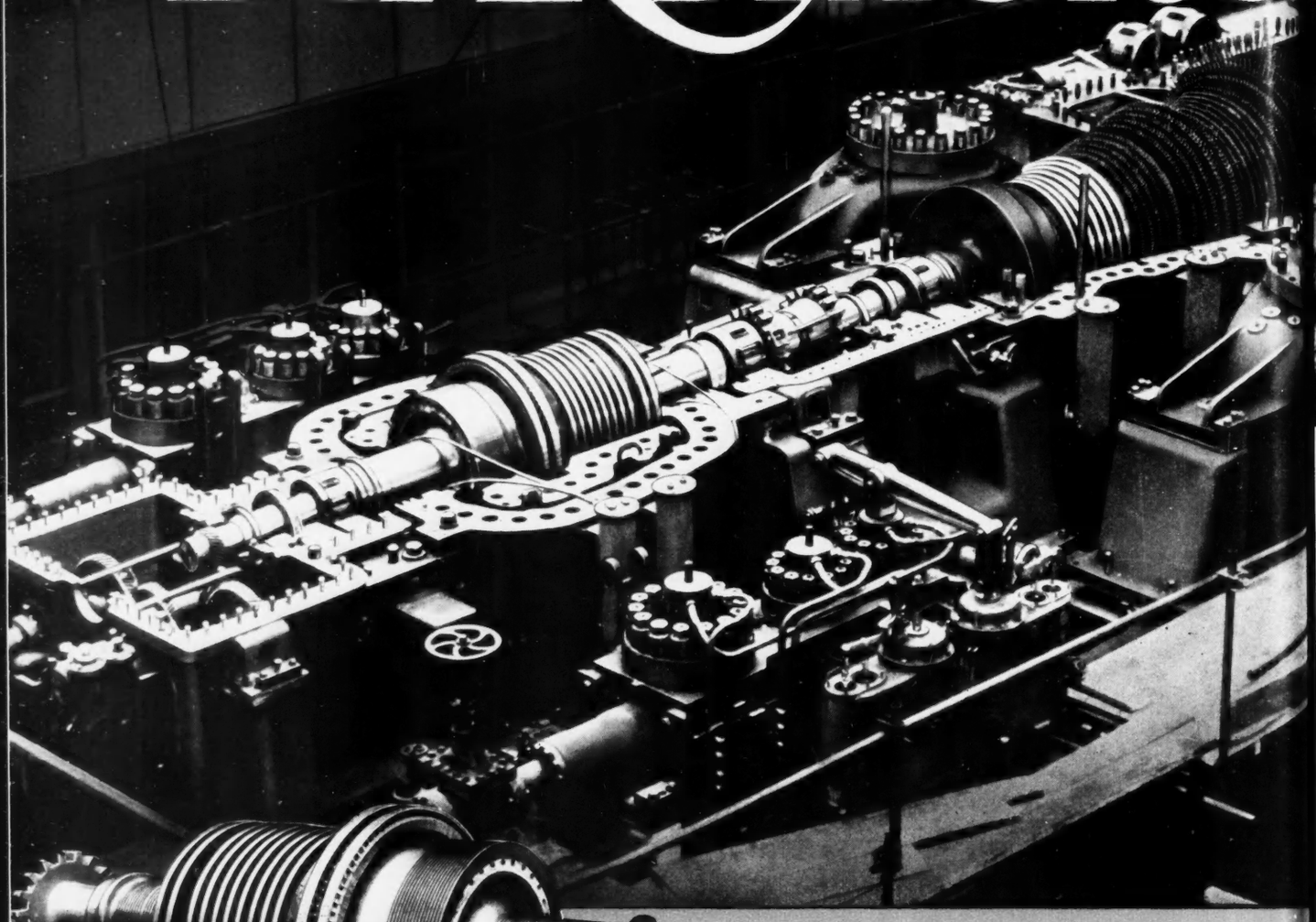
On left: Safway Scaffolding supporting a Gas Main built by the Coppee Company Ltd.

Cogent

See us on Stand B.4. Engineering, Marine, Welding and Nuclear Energy Exhibition, Olympia, 29th August—12th September

L

BEARDMORE



H.P. turbine shaft installed during construction of 100 MW Power Station turbo-generator at the Heaton Works of C. A. Parsons & Co. Ltd.

forgings and castings in carbon and alloy steels for electrical and general engineering purposes

WILLIAM BEARDMORE & CO. LIMITED

PARKHEAD STEEL WORKS · GLASGOW E1

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XUM

Aug. 2

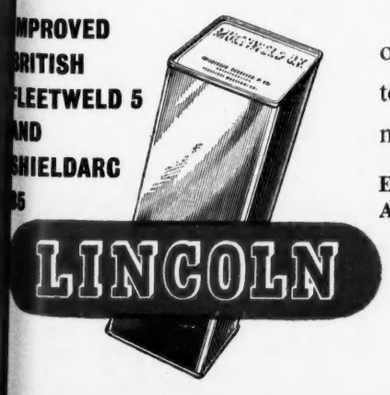
LINCOLN ELECTRIC SERVES THE INDUSTRY OF THE WORLD 10

Thames Haven to Romford Pipeline

In constructing this 17-mile 24-inch welded steel pipeline for the North Thames Gas Board and Shell-Mex and B.P. Ltd., Messrs. William Press & Son Ltd., are extensively using Lincoln Diesel Welding Units, Improved Fleetweld 5 and Improved Shield Arc 85 electrodes.

The agreement, that from mid-1958 Shell Haven Refinery will be transmitting to Romford 25 million therms of gas per year, largely depends on faultless pipework. The contracts call for the highest standard of welding, and ultrasonic testing is being used in conjunction with radiography by Messrs. Metal and Pipeline Endurance Ltd. in their inspection and double-checking for weld quality.

The combination of Improved Fleetweld 5 and Improved Shield Arc 85 is being extensively used on all pipelines where the 'stove pipe' welding technique, high speeds and high mechanical joint efficiency are required.



Improved Fleetweld 5 conforms to B.S. 639:1952 and is approved by Lloyd's Register of Shipping and the Ministry of Transport and Civil Aviation. It is also being used extensively in the expansion now taking place within the British Petroleum Industry, and the newly developing Petro-Chemical Industries.

ENGINEERING MARINE, WELDING AND NUCLEAR ENERGY EXHIBITION at Olympia, 29th August—12th September. See Lincoln Electric on Stand No. 4. Row U, Empire Hall.

Largest manufacturers of D.C. Welders in the United Kingdom

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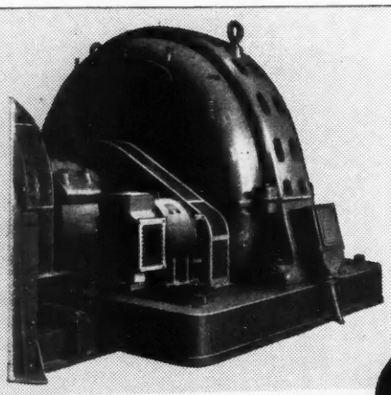
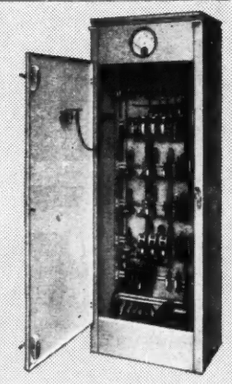
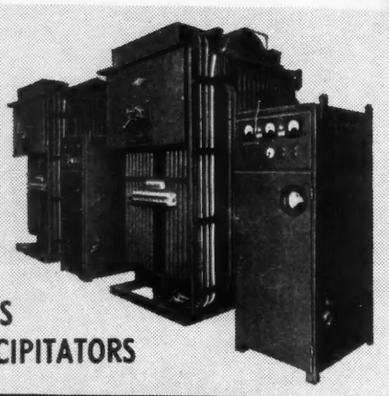
ROTATING MACHINES



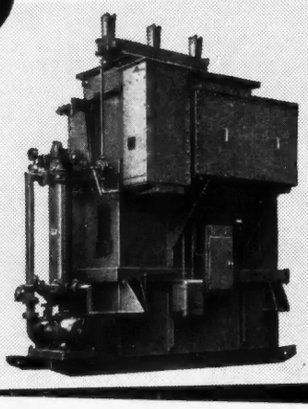


CONTACTOR TYPE SWITCH GEAR

ECC



RECTIFIERS FOR PRECIPITATORS



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THE ELECTRIC CONSTRUCTION COMPANY LTD.

BUSHBURY ENGINEERING WORKS · WOLVERHAMPTON

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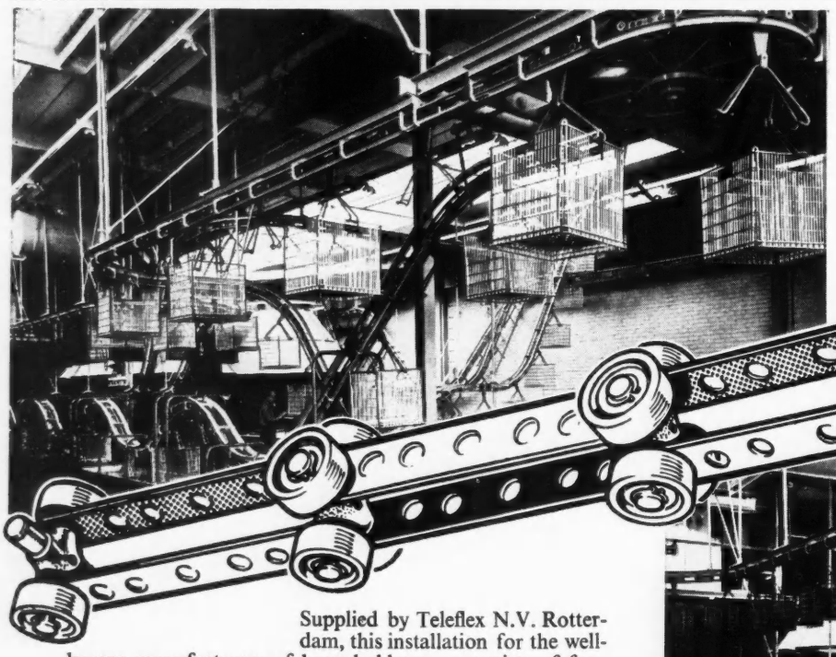
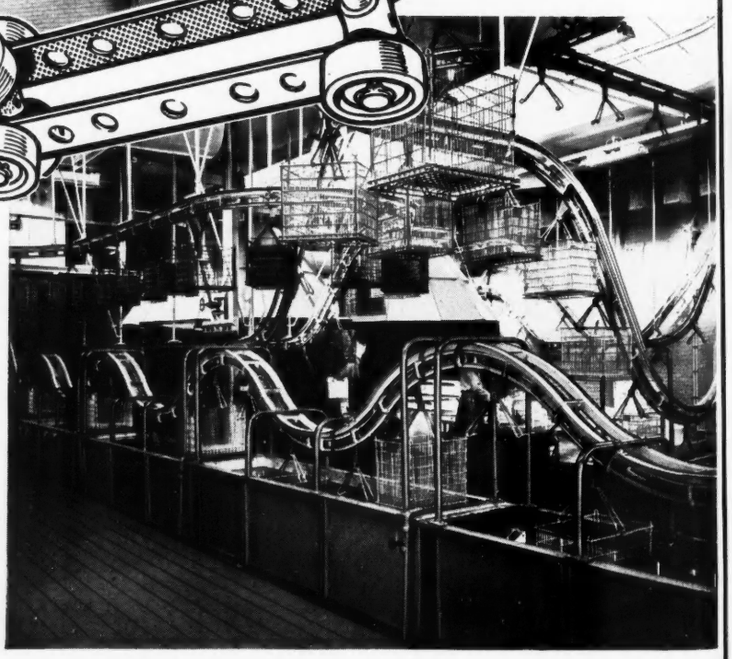


TELEFLEX

DUAL DIRECTIONAL CHAIN CONVEYOR

installed for TOMADO N.V. of ETTEN-LEUR, HOLLAND



Supplied by Teleflex N.V. Rotterdam, this installation for the well-known manufacturers of household ware consists of four dual-directional chain conveyors with a total length of 400 metres.

Illustrations show the extreme adaptability of the Teleflex Dual-Directional system for travel at any angle, around corners and on curves of both horizontal or vertical planes and its outstanding suitability for dipping, finishing or other processes. The long experience of our advisory staff is entirely at your disposal.

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CHADWELL HEATH · ESSEX

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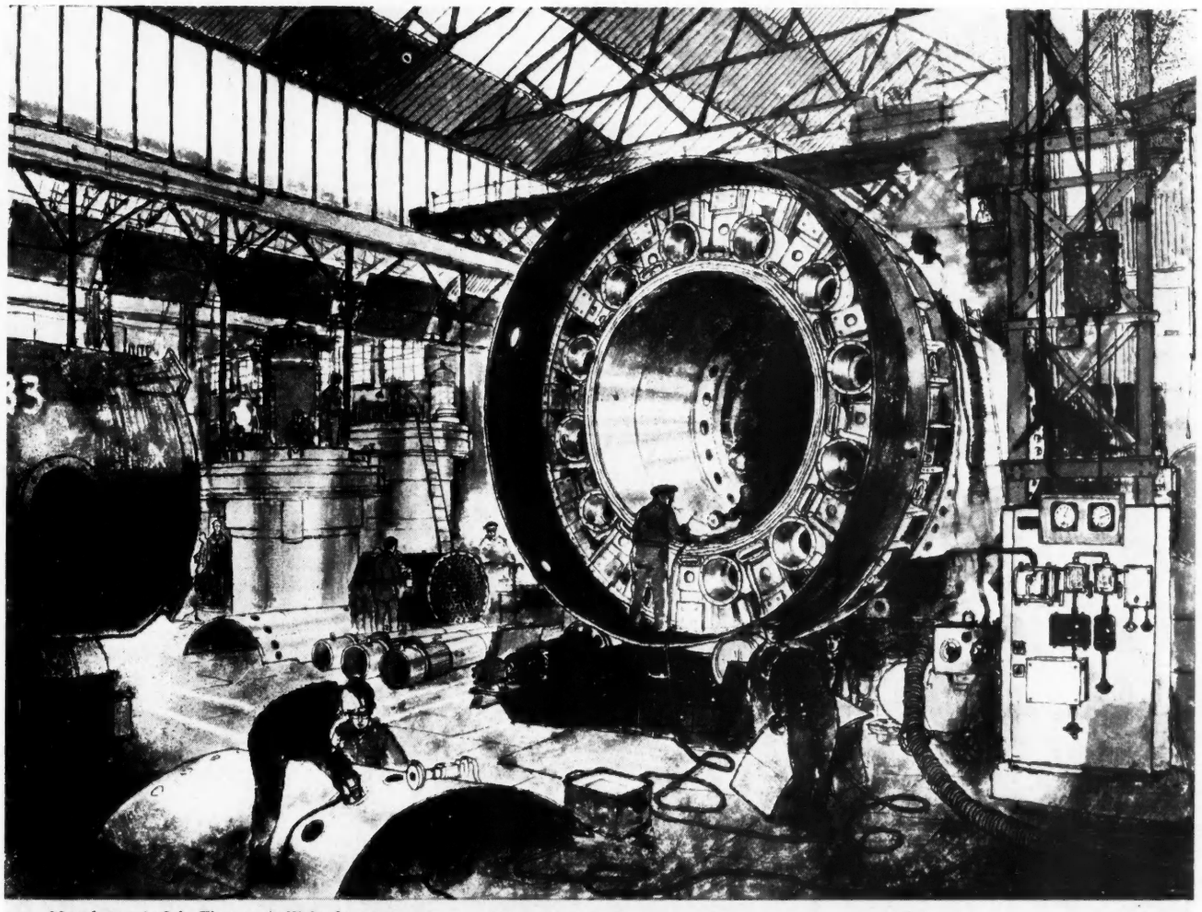
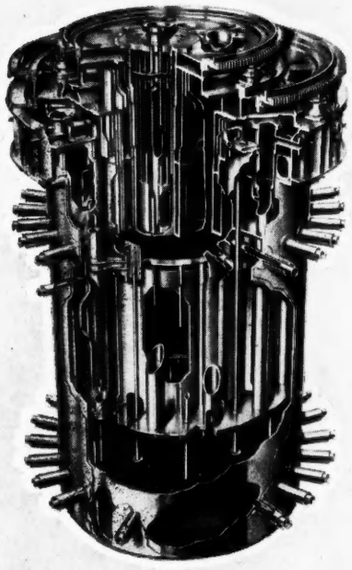
ALSO MANUFACTURERS OF THE WORLD RENOWNED TELEFLEX CONTROLS



Manufacture in John Thompson's Wolverhampton Works for the U.K. Atomic Energy Authority's Fast Breeder Reactor at Dounreay.



The most complicated stainless steel vessel ever made

The Dounreay reactor vessel is a complex 45-ton stainless steel vessel with eccentric rotating top shields and will contain the core, breeder blanket, control rod operating mechanisms, recording instruments and the liquid-metal which is circulated to the primary heat exchangers. Every welded joint was radiographed, requiring 3750 negatives. The whole unit is manufactured to very fine tolerances—0·1% circularity, 0·03% alignment and almost perfect concentricity.

John Thompson are also manufacturing the stainless steel liquid-metal circuits, primary and secondary liquid-metal heat exchange systems and complete steam and water equipment with boilers and other plant.

JOHN THOMPSON WATER TUBE BOILERS LIMITED · JOHN THOMPSON GROUP

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WTB/12

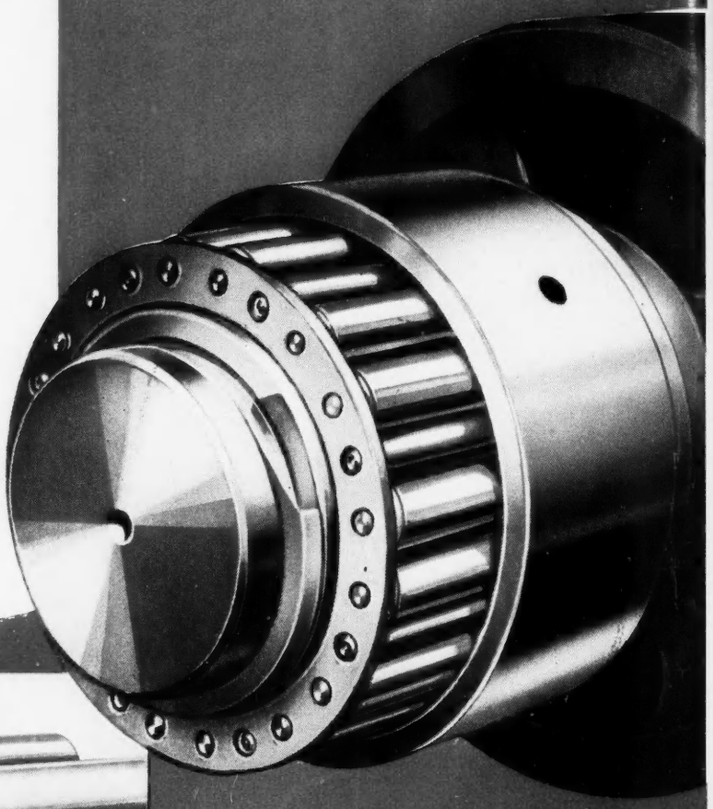
POLLARD

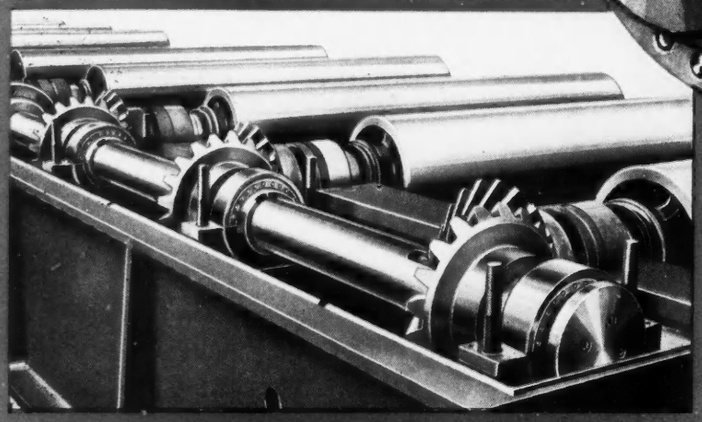
HEAVY DUTY ROLLER BEARINGS

APPLIED TO THIS ROLLING MILL RUN-OUT ROLLER TABLE

MANUFACTURED BY

W. H. A. ROBERTSON & CO. LTD BEDFORD





Full range of solid, flexible and 'Max-Load' Roller bearings available from 10 m/m to 350 m/m shaft diameter. All interchangeable with and equivalent to bearings of American type and manufacture.

Ask for Catalogue MAX/54.

Photographs by courtesy of Messrs. W. H. A. Robertson & Co. Ltd., Bedford.

Pollard heavy duty Roller bearings support both the line shaft and the roller shafts of this run-out table.

Other catalogues available. Solid and Flexible Roller Bearings. Also Ball, Roller, Thrust Bearings (Cat. BRT. 1053) Transmission Equipment and Plummer Blocks (Cat. T.R. 27/2) Self-Lube Plummer Blocks (Cat. SL/57) Automobile and Tractor Replacements (Cat. BRM/54) Clutch Withdrawal and Water Pump Spindle bearings (Cat. CWFP/54).

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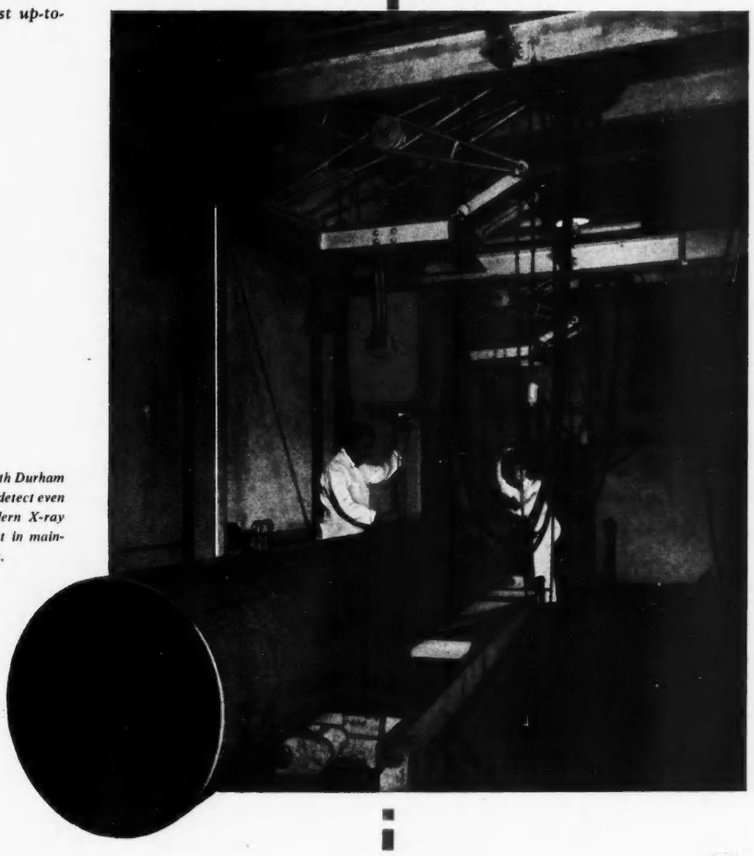
South Durham

The South Durham Steel and Iron Company Limited first began to manufacture large diameter steel pipes in 30-foot lengths for the conveyance of oil, water, gas and for hydro-electric projects in 1926. Since then the Company has made immense strides in pipe production and its specialist plant at Stockton-on-Tees which now manufactures pipes up to 40-feet in length is acknowledged to be the largest and most up-to-date in the United Kingdom.



Right : The X-ray room at the South Durham pipe mill. Because of its ability to detect even the smallest flaw in welding, modern X-ray equipment plays an important part in maintaining the quality of the product.

STEEL PIPES

To manufacture steel pipes capable of meeting the exacting requirements of the highest British and American specifications calls for rigid quality control at every stage of production.

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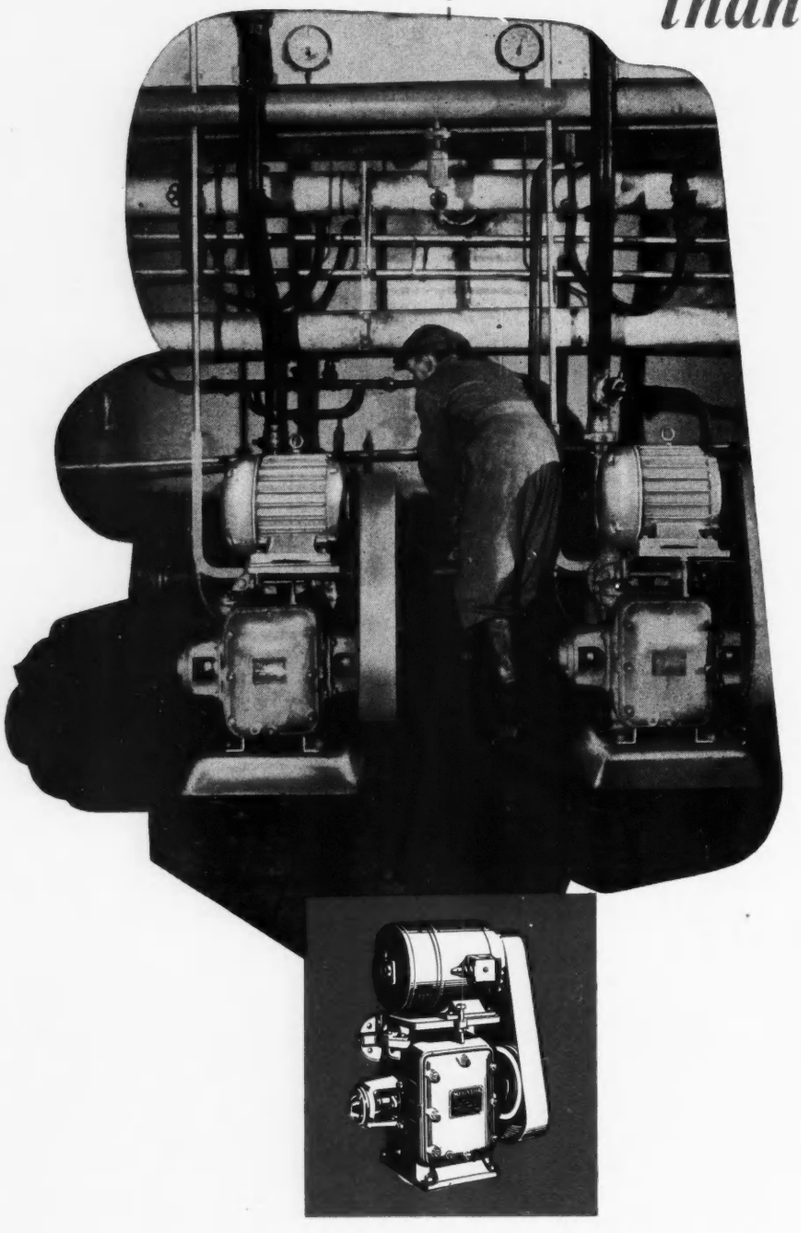

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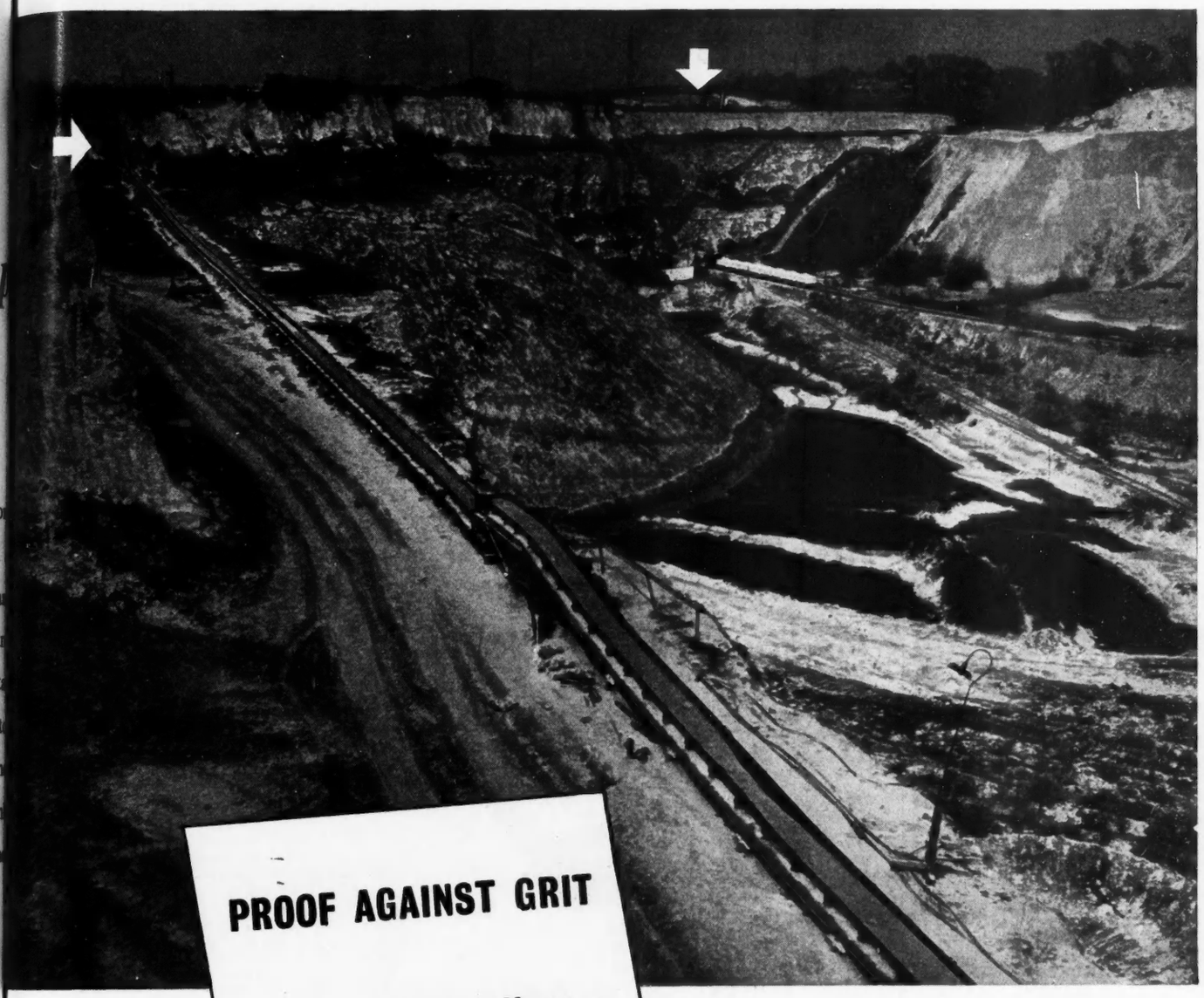
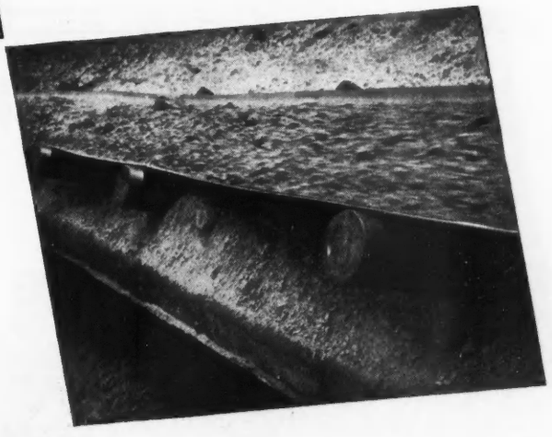


PROOF AGAINST GRIT

★ M & C idler rollers ★

The conveyor line passes through the tunnel on the left, and is marked in the distance by the further arrow.



From a great chalk-pit, M & C belt conveyors carry up to 3,000 tons a day of sandy overburden to the disposal ground about a mile away. For eight years, the idlers have been resisting the weather, keeping out the wind-blown grit that swirls around them, and ensuring reliable transport, twenty-four hours a day, seven days a week.

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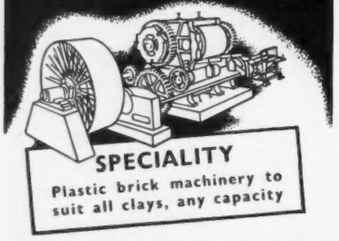

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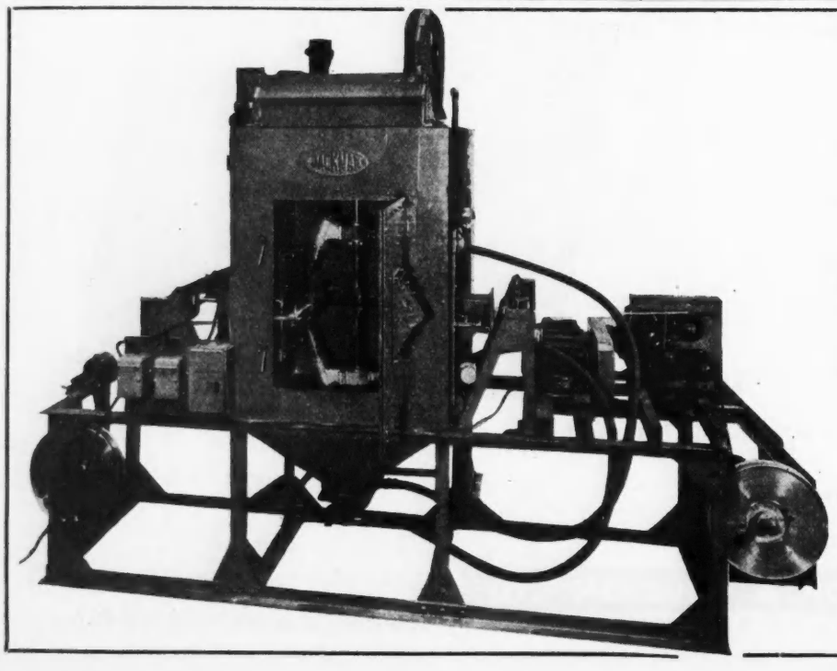

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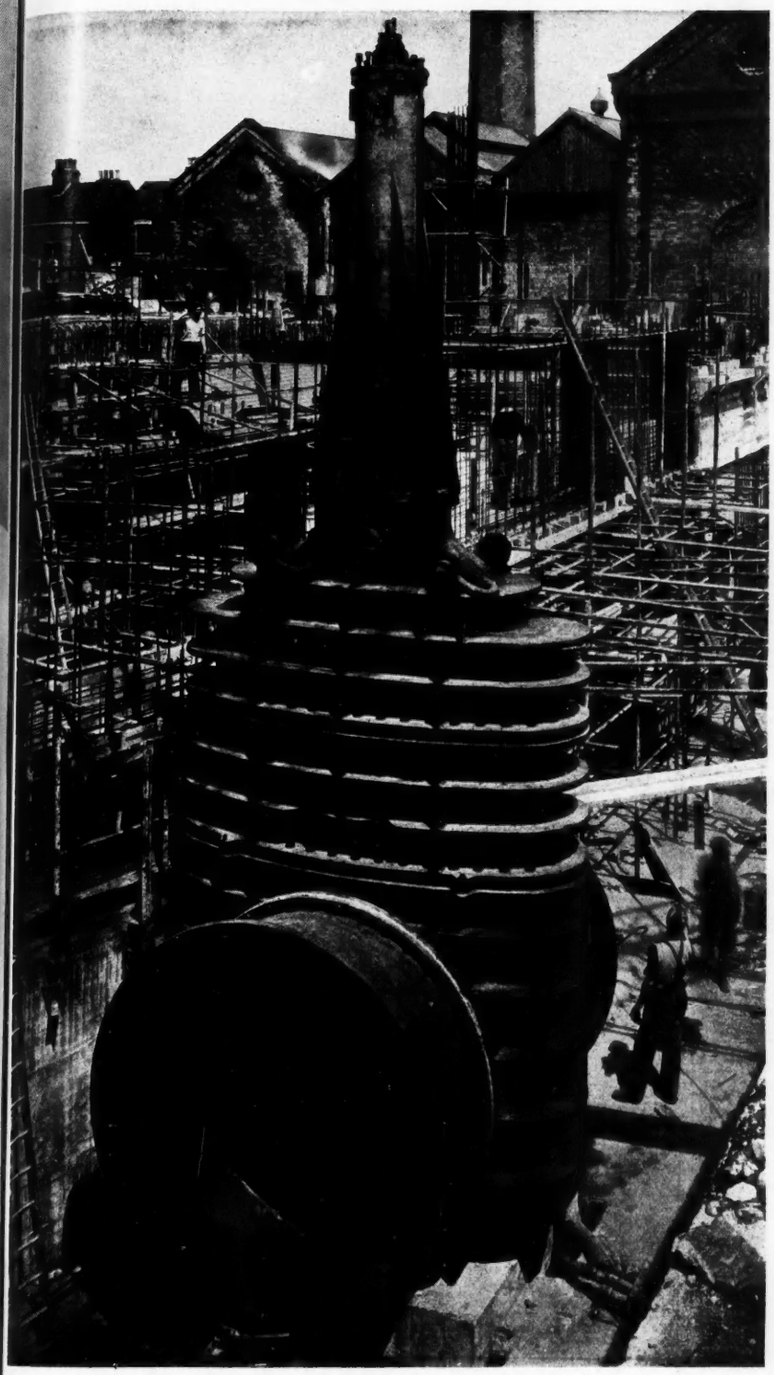

Large Sluice Valves at Humberside Pumping Station

WEST HULL & HALTEMPRICE

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Two of the largest individual components on the recently inaugurated Humberside Pumping Station — itself probably the largest of its kind in Europe — are the 90in. diameter Blakeborough sluice valves on the discharge culverts to the main outfall. These valves, which weigh upwards of 35 tons apiece, are of electric motor operated type, and equipped for fully automatic control. The photograph, taken while civil engineering construction was still proceeding, shows one of the valves in course of erection on site.

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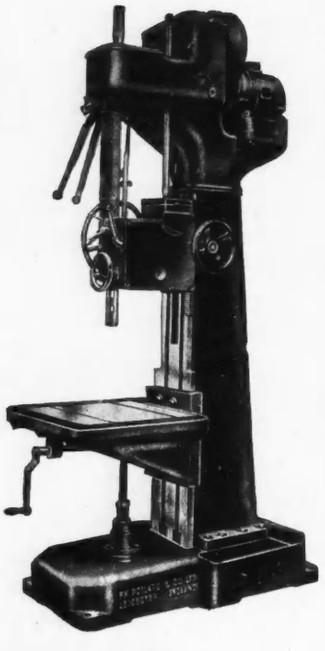

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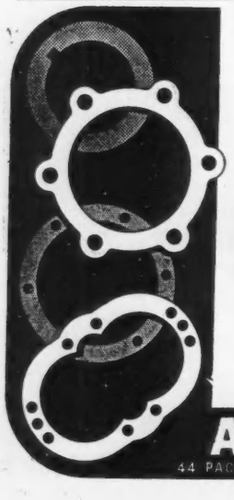

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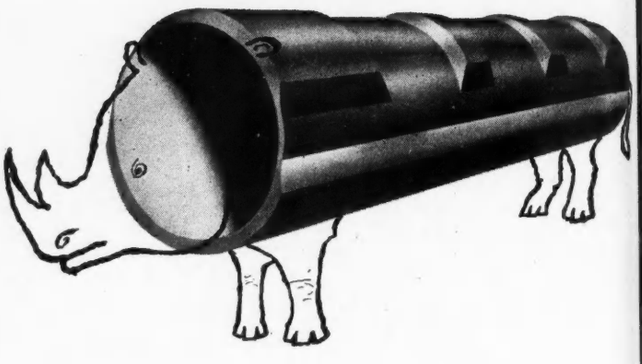

Dash it all—I've fairly peppered the brute and every shot bounces off!

Perhaps a twenty-five pounder is called for.

Doubt whether that would do either. Haven't you noticed . . .

By jove! *Seamless* steel. Not a weld or a weak spot anywhere!

Quite. Let's creep quietly away, old man, before *it* notices *us*.

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The marine boiler drum illustrated was machined externally to form tube and wrapper plates and pads. It is 14 ft. 6 ins long and has an internal diameter of 30 ins. Tubes of this calibre we take in our stride; in fact, we're game for any size you want.

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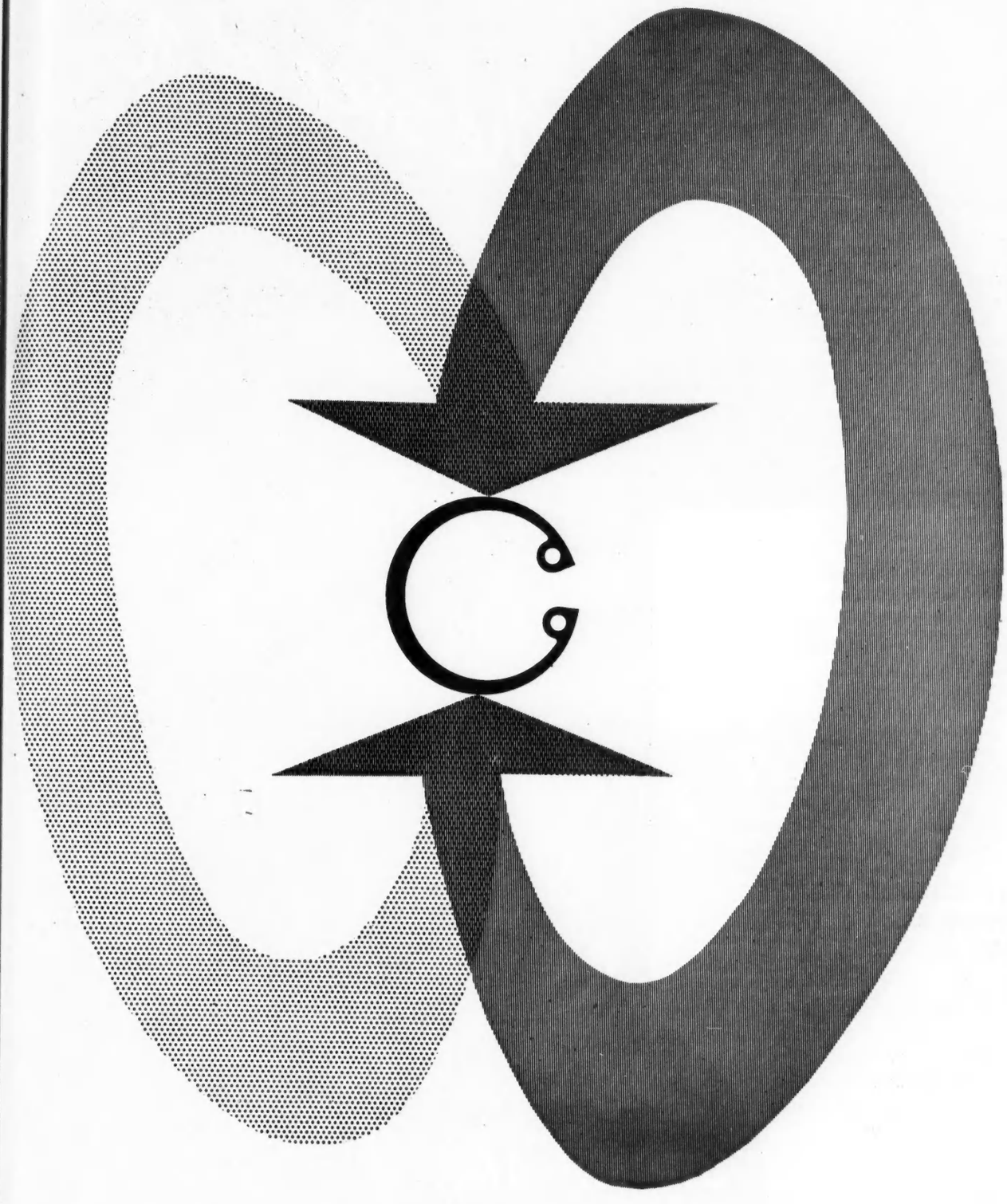

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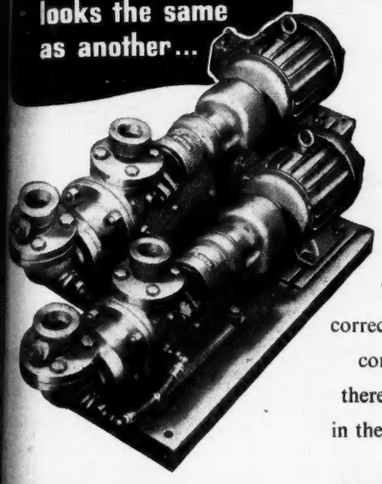

. . . but do not be deceived by outward appearance. The parts for an industrial Mono Pump are carefully related to the liquid and to the conditions of pumping. Tests are made to ensure the correct materials are used for its construction. It does not end there—we always take an interest in the pump after it has been sold.

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The MONO pump

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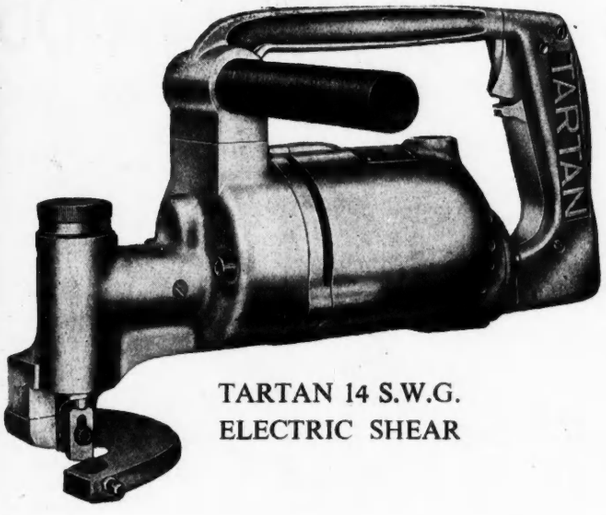

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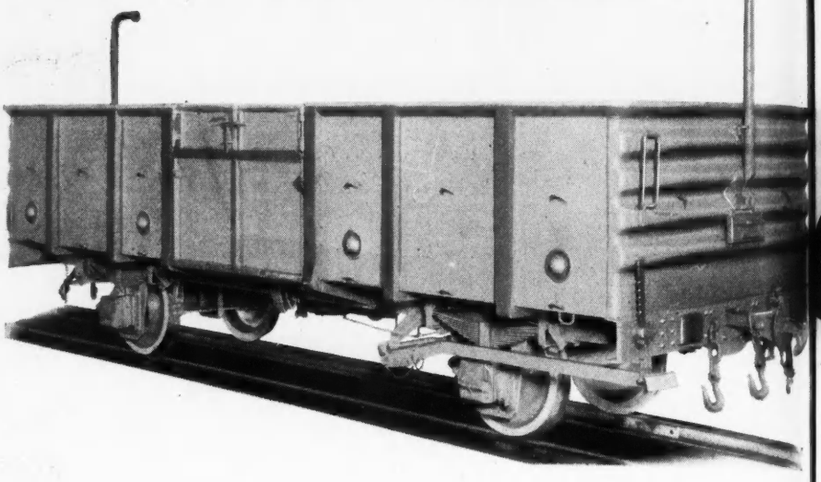

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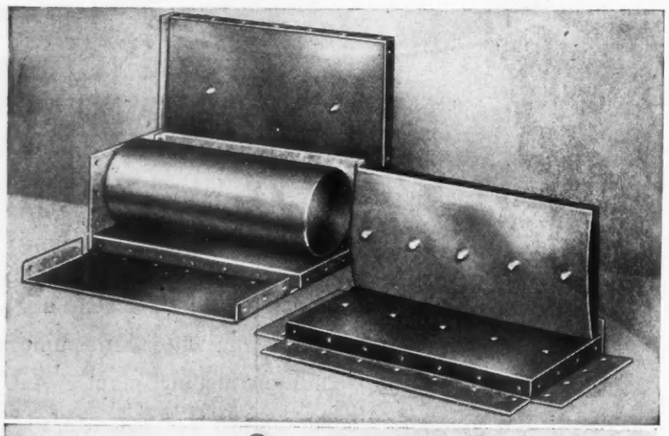
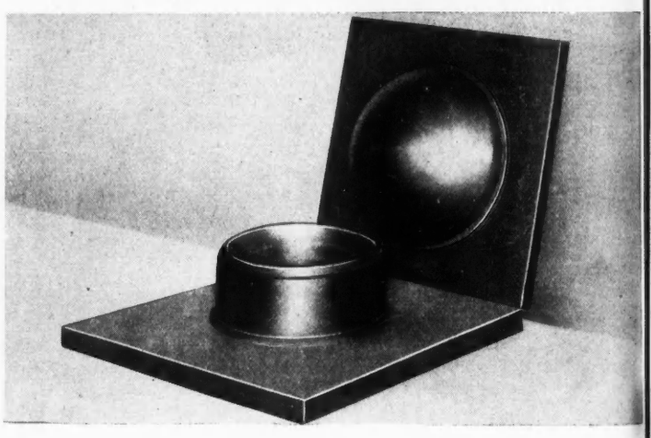
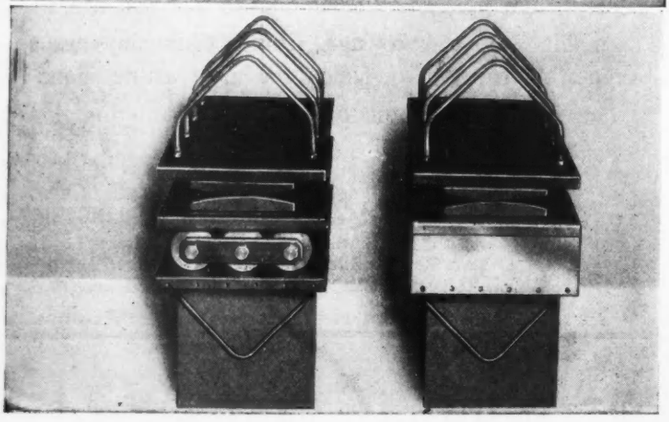
Bridge Bearings by **WESTWOODS**







Illustrated are a few examples of various Bridge Bearings recently constructed by Westwoods.

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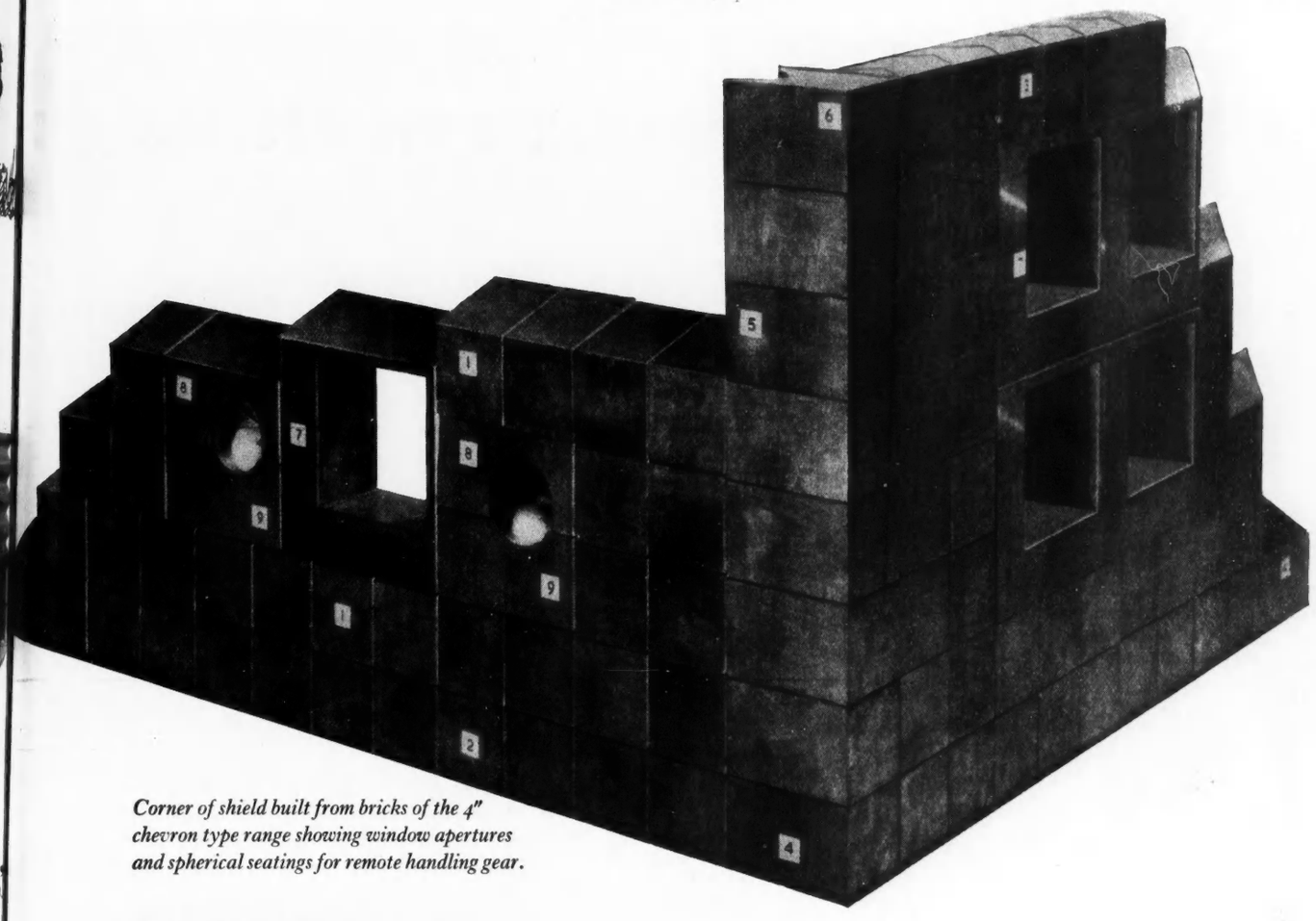
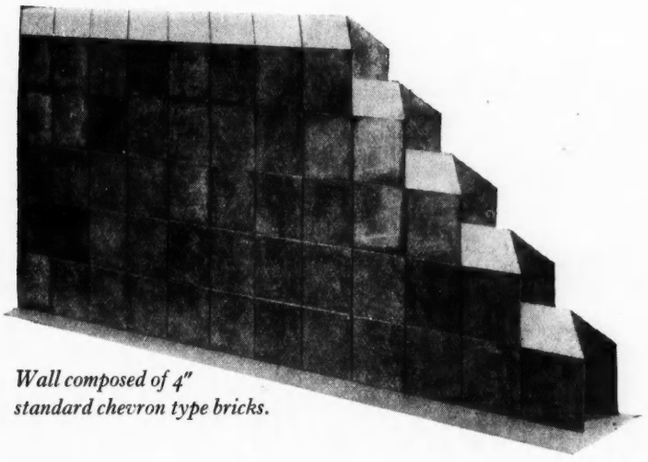


Corner of shield built from bricks of the 4" chevron type range showing window apertures and spherical seatings for remote handling gear.



Wall composed of 4" standard chevron type bricks.

LEAD SHIELDING

Some of the lead bricks we supplied to the United Kingdom Atomic Energy Authority are shown in these photographs. The people to consult about the production of special shapes for shielding are Associated Lead.

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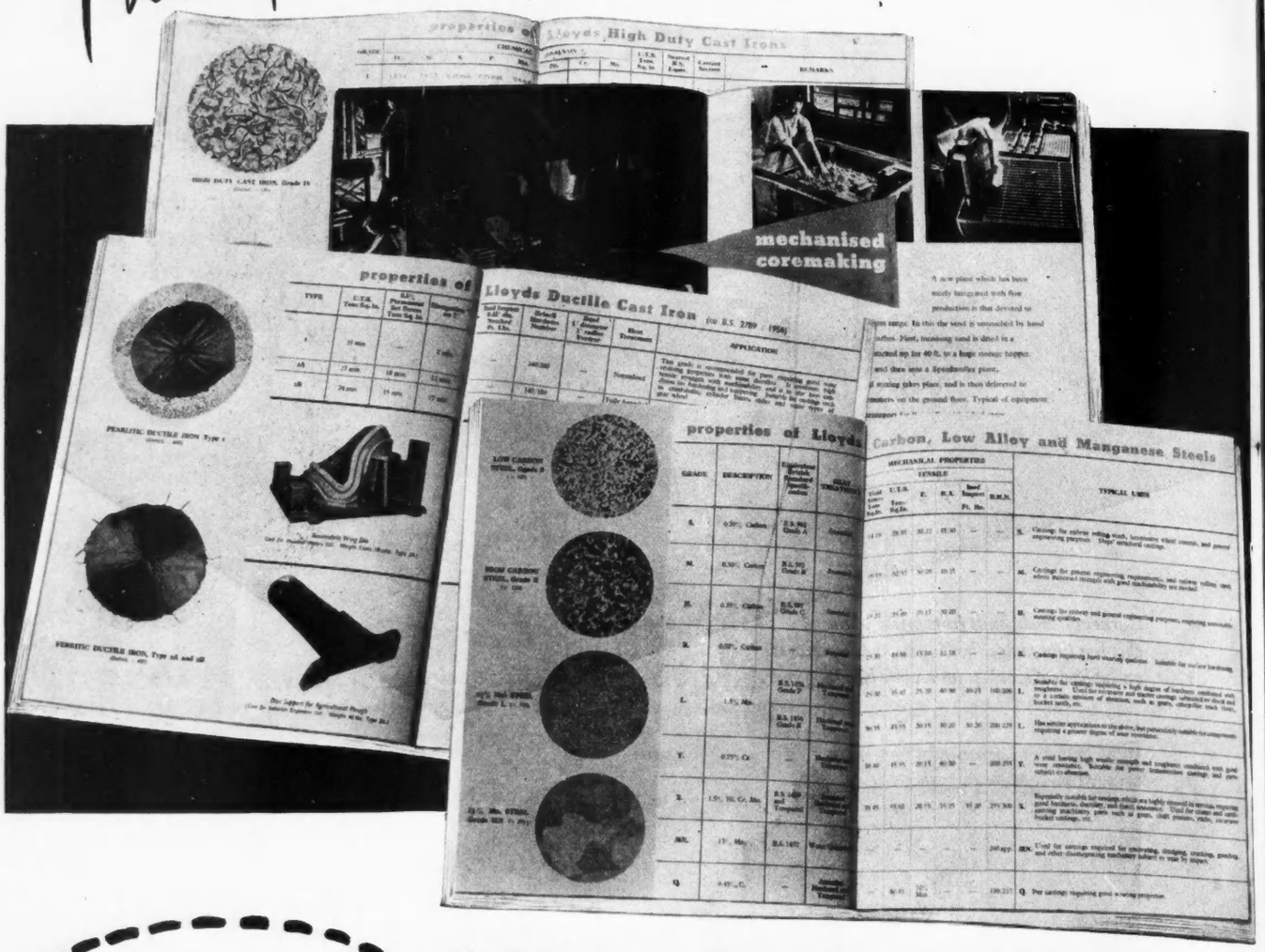
N

Flow production of iron and steel castings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68 Pages of ferrous foundry processes & specifications of

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ALLOY STEELS
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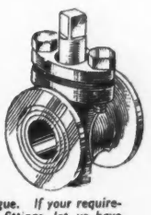
★ Of interest to Water Engineers —Send for details of Water Ferrules and Plug Taps.



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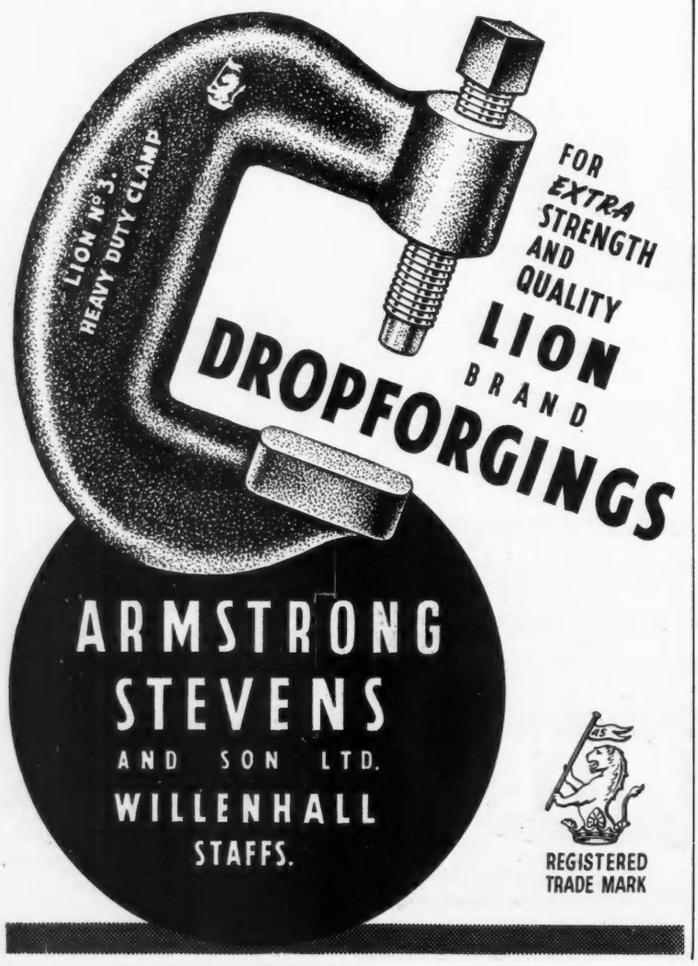

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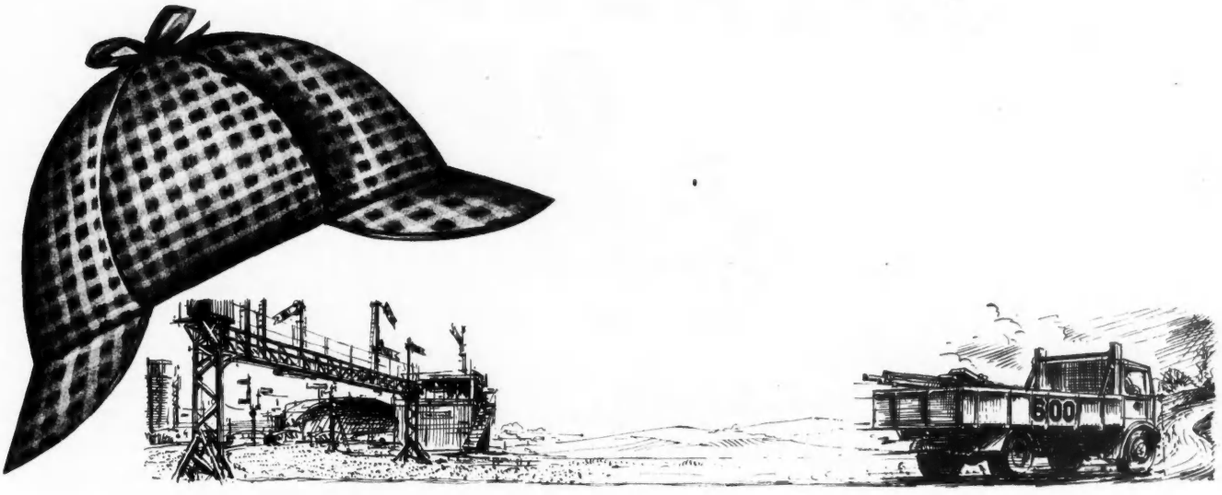

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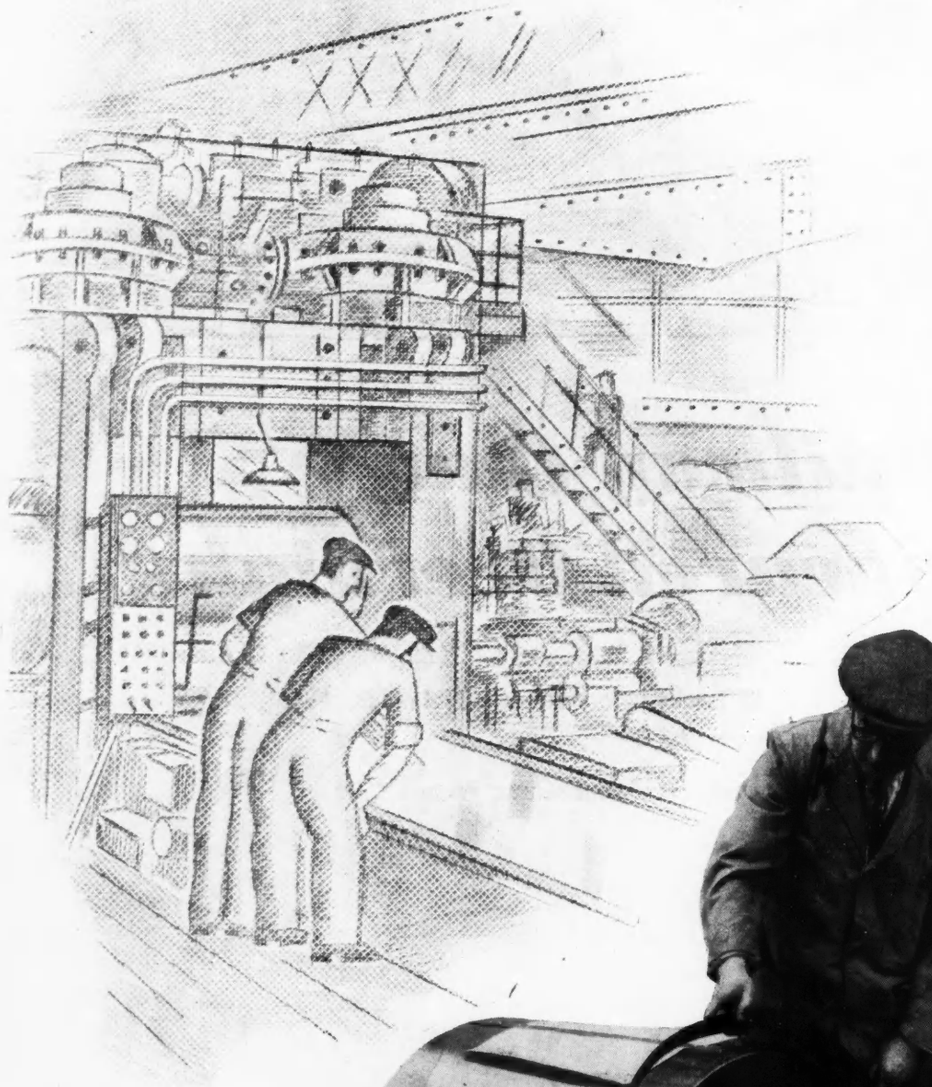

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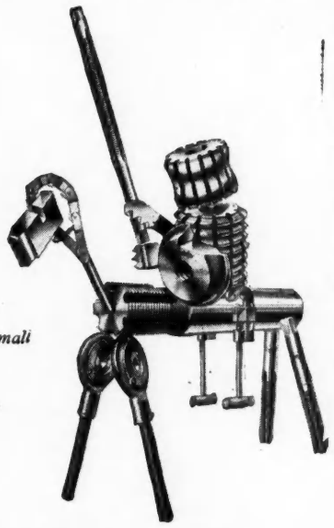

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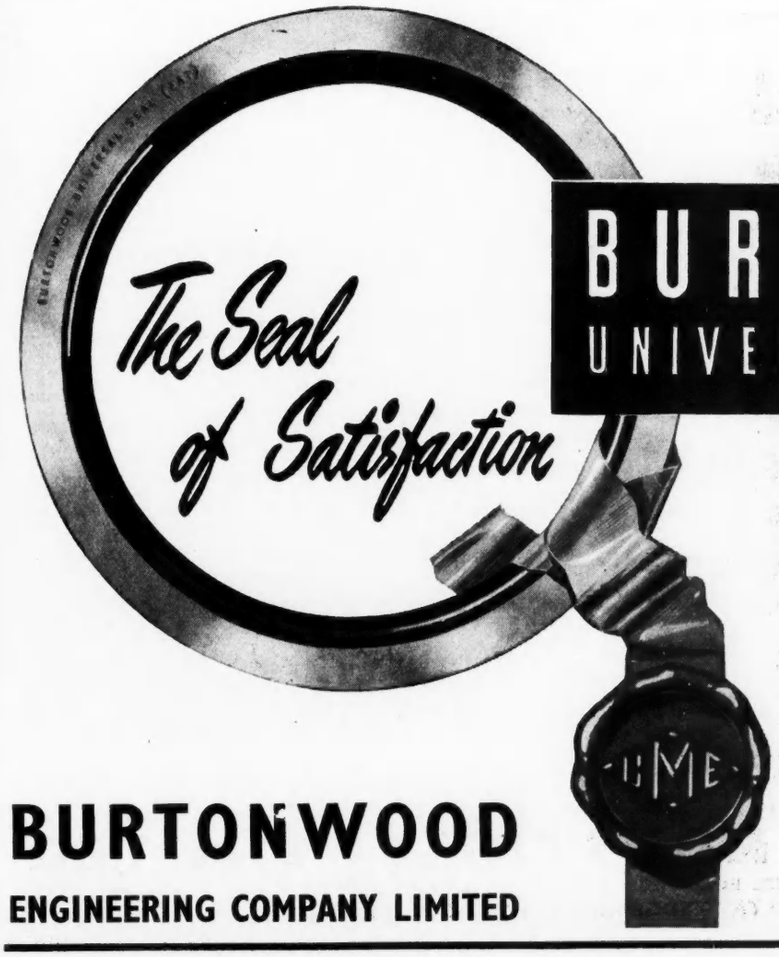

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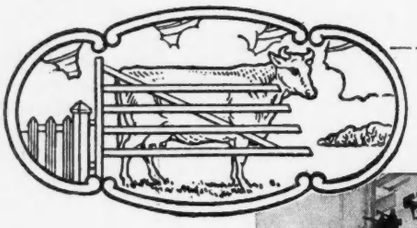

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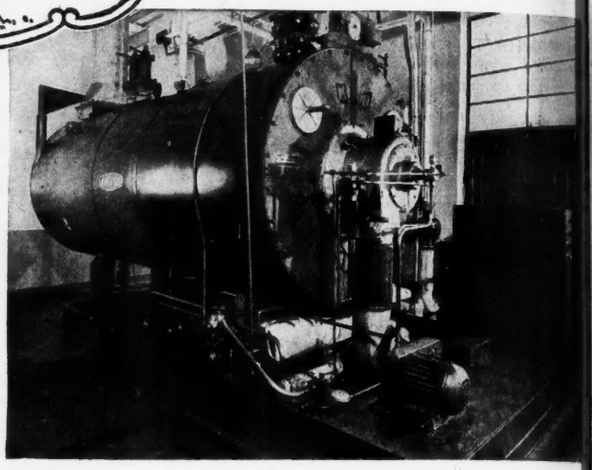

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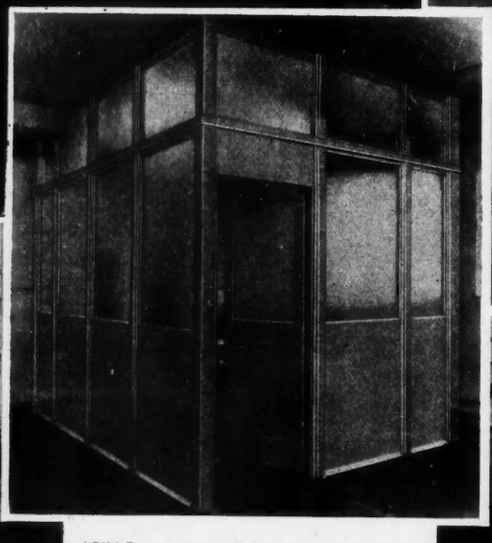

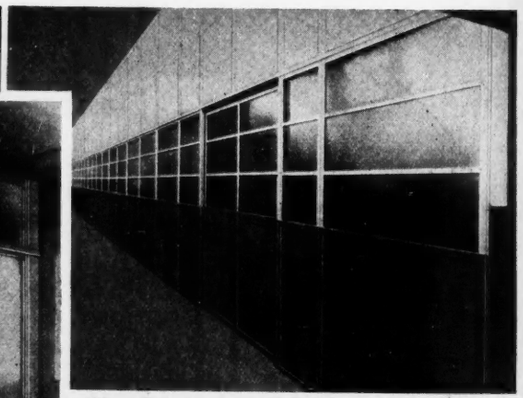

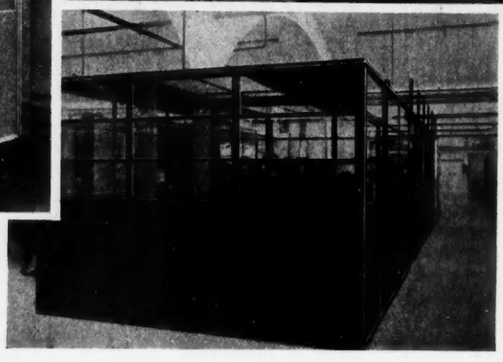

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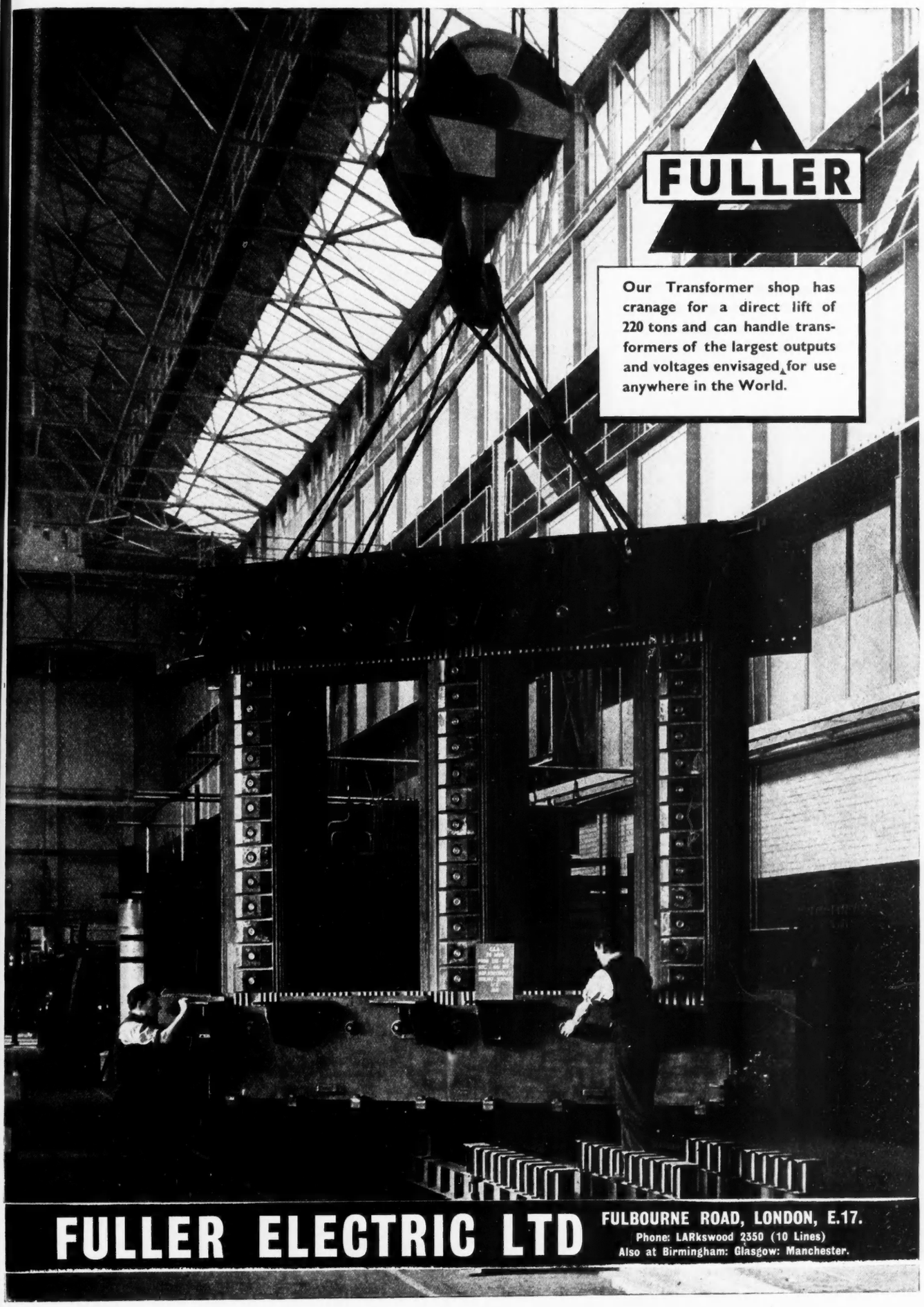
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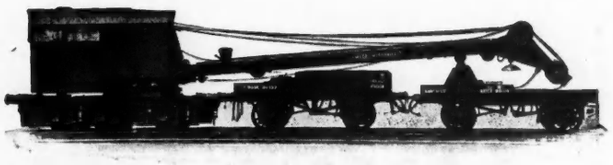

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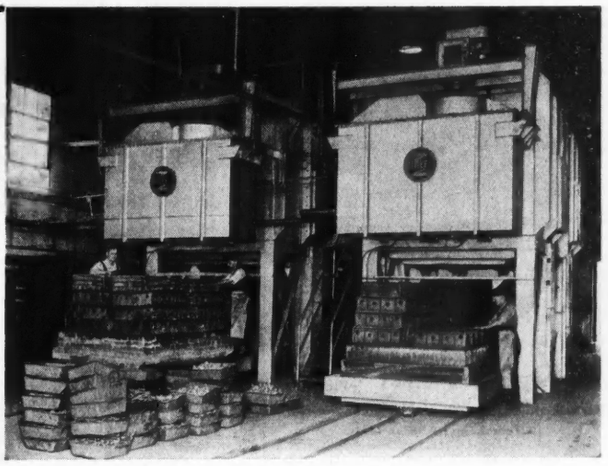

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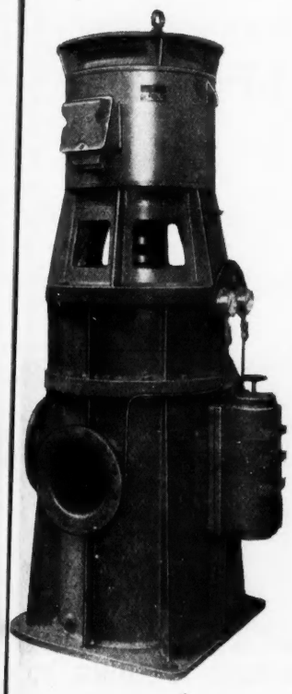

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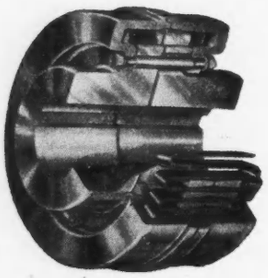

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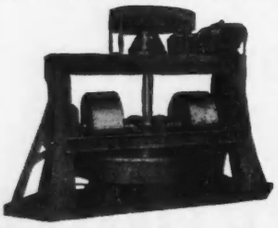

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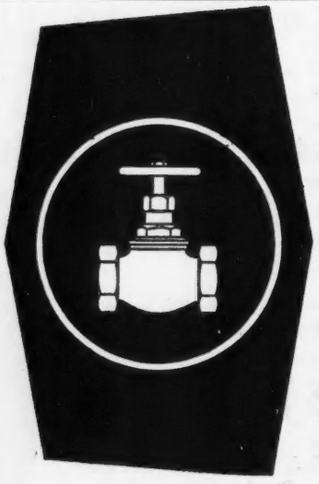

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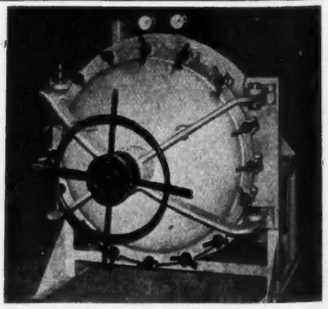

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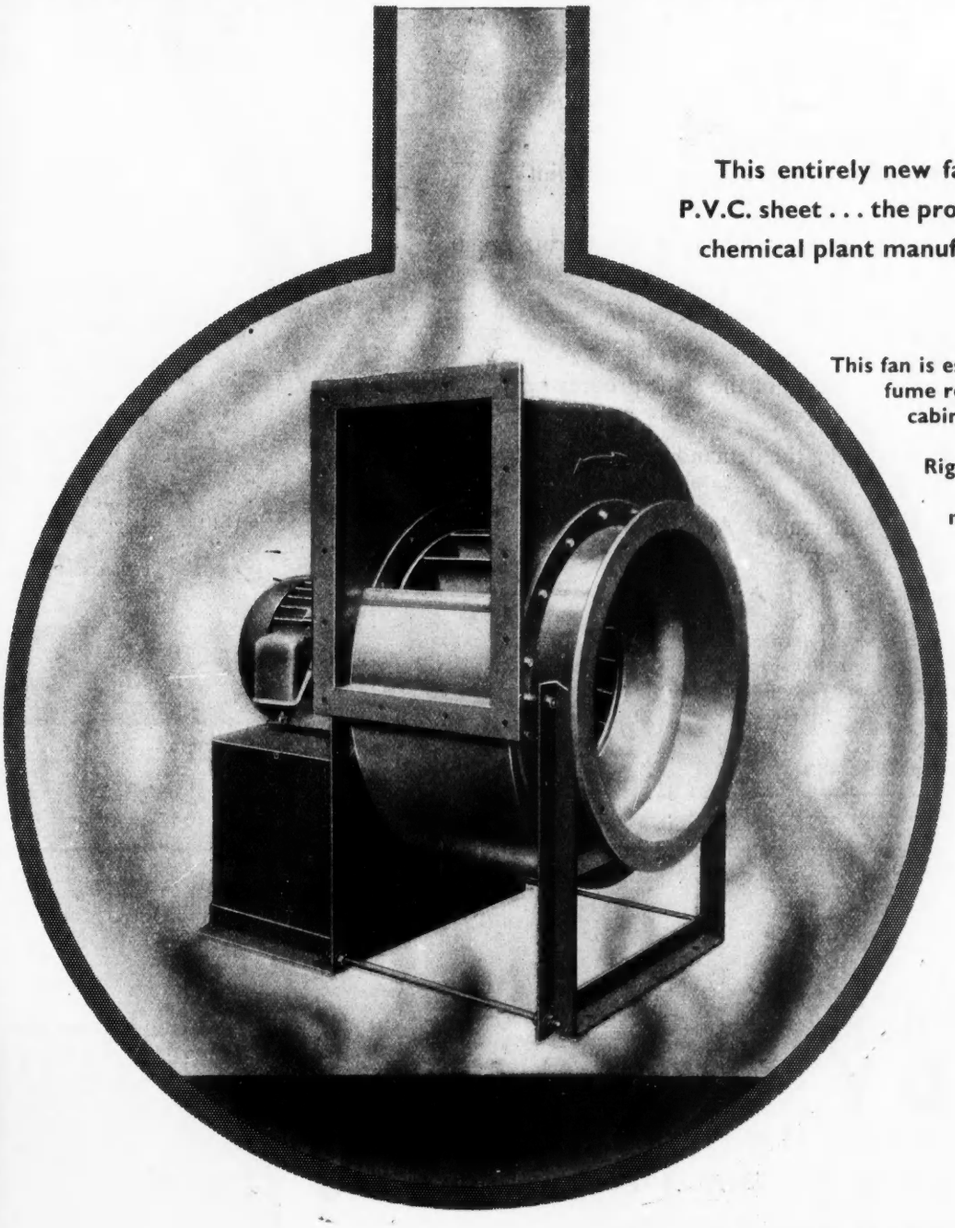

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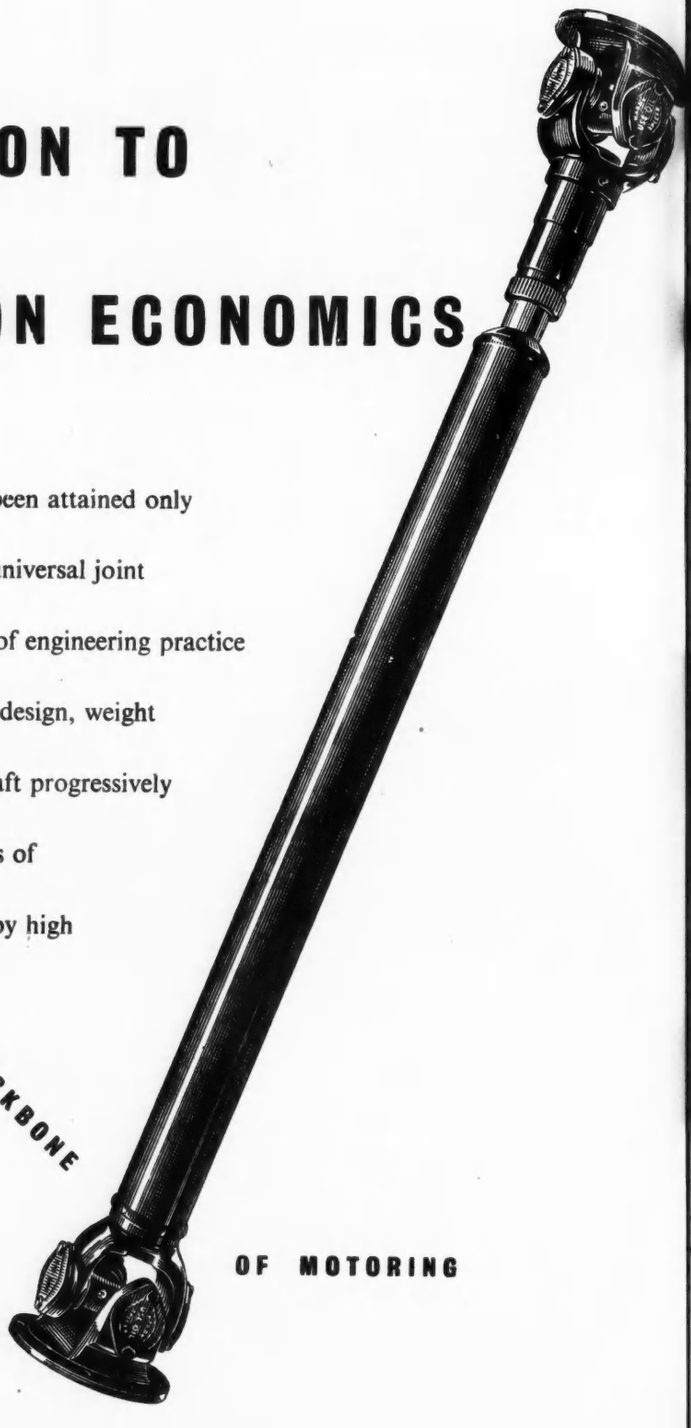

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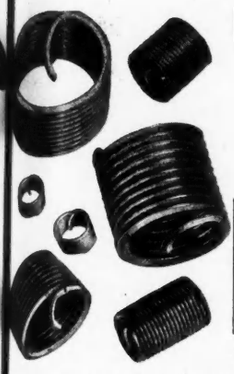

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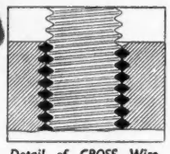

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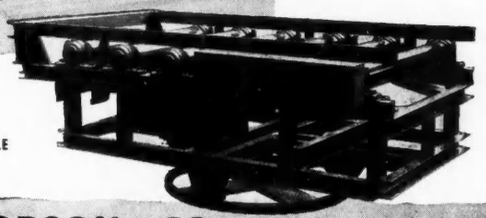

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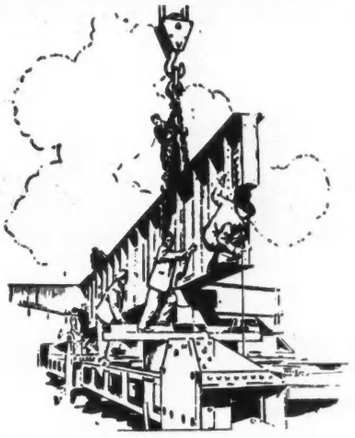

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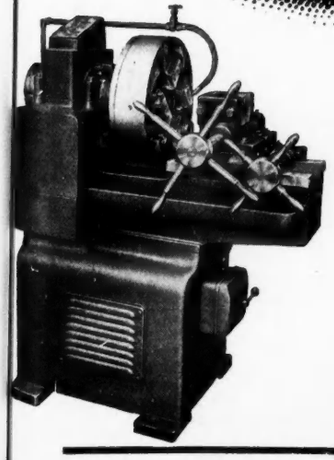

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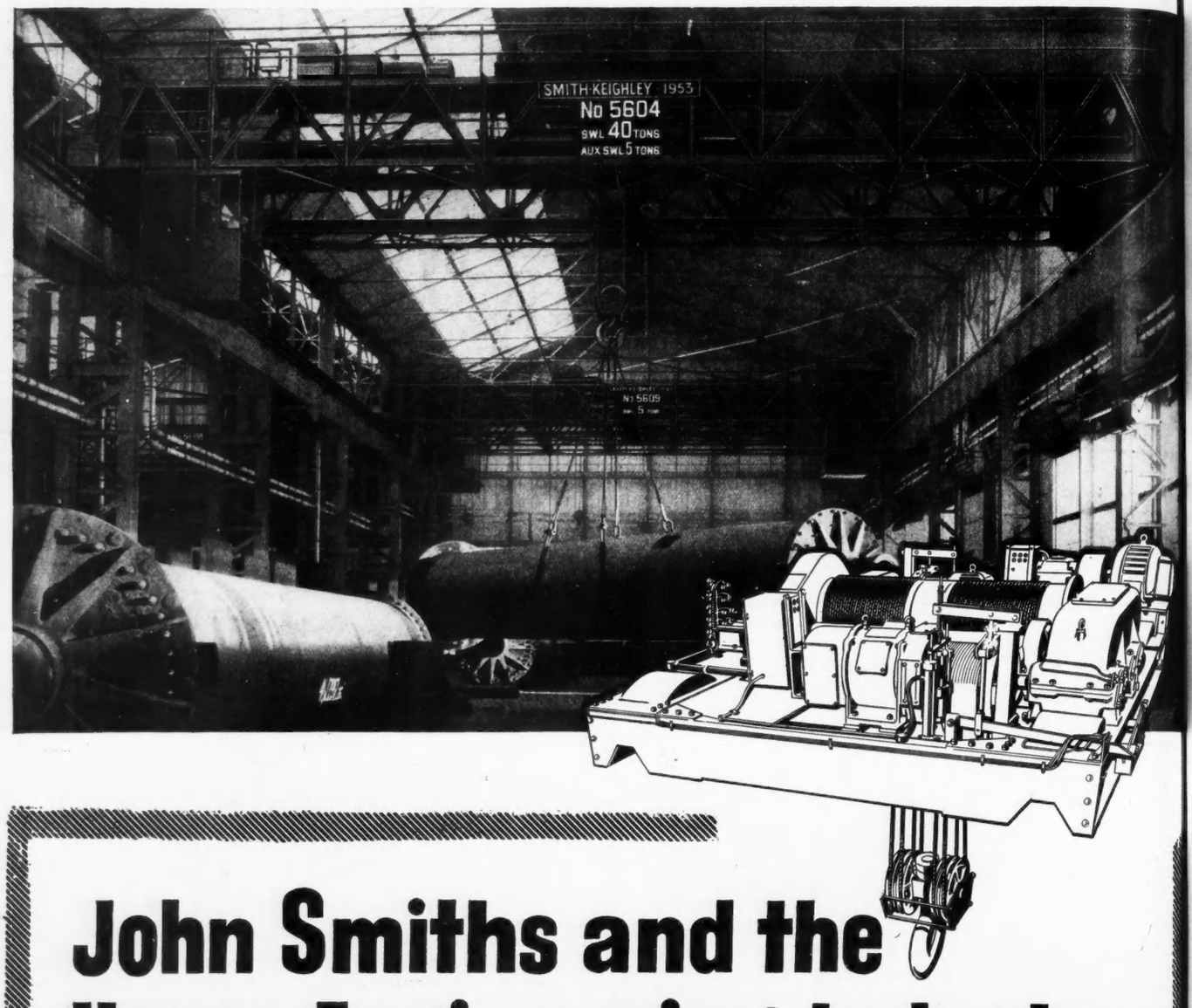

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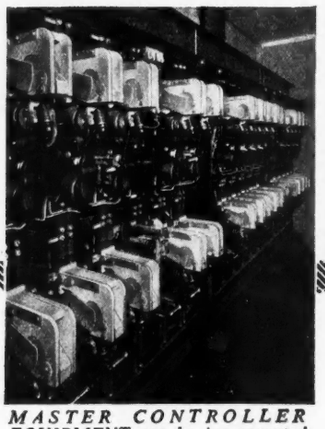

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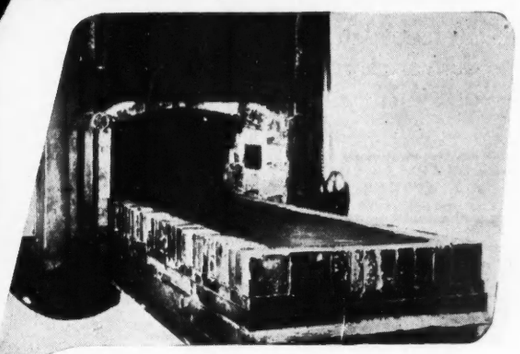
BOGIE TOPS

Examples of another of the many uses for REFRACTORY CONCRETE

Atlas Steel Foundry. Bogie for mould drying stove, topped with Refractory Concrete. Bogie is 25′ long and 10′ wide, the topping being 6″ thick. The door shown is lined with Ciment Fondu insulating concrete



Wm. Jessop & Sons Ltd. Bogie is 15′ long by 5 wide topped by 6½″ of Refractory Concrete

—Because its monolithic construction eliminates troubles due to displacement of bricks

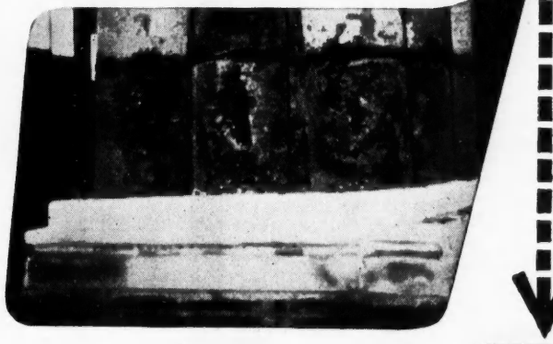
—It will withstand severe thermal shock without spalling

—It is ready for use and of great strength and hardness in 24 hours

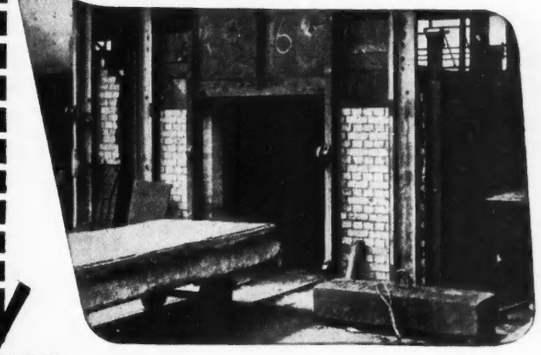
—It has no appreciable drying shrinkage or after-contraction

—It is stable under load up to 1300°C. (2400°F.)

Bogie used at large Northern Foundry, in gas-fired tunnel oven, for annealing malleable iron at 1050°C. Bogie is 7′ x 7′ and the Refractory Concrete decking is 12″ thick.



Crossley Bros. Ltd. Bogie for gas-fired annealing oven operating at 650°C. The door is also lined with Refractory Concrete



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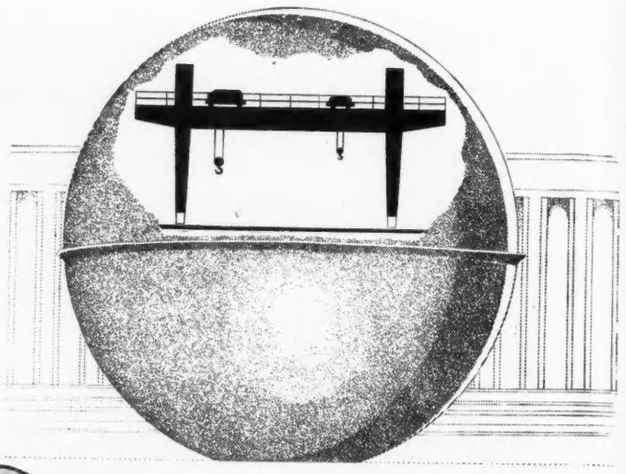

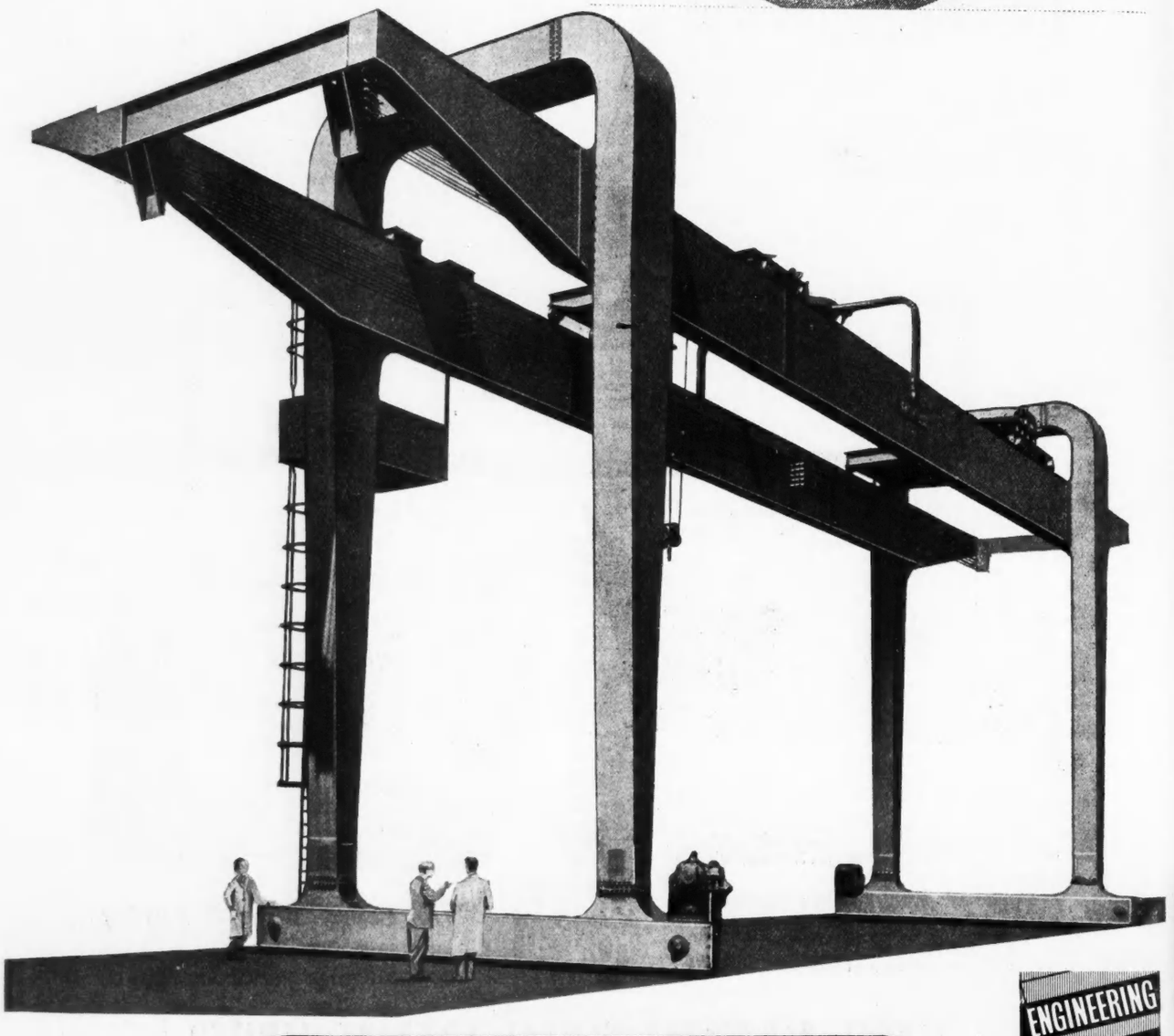

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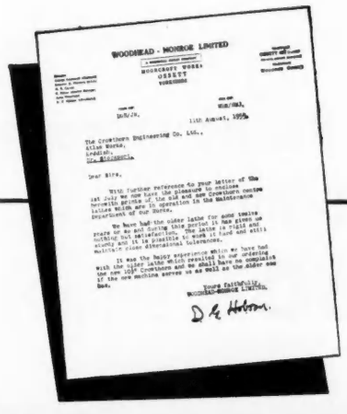

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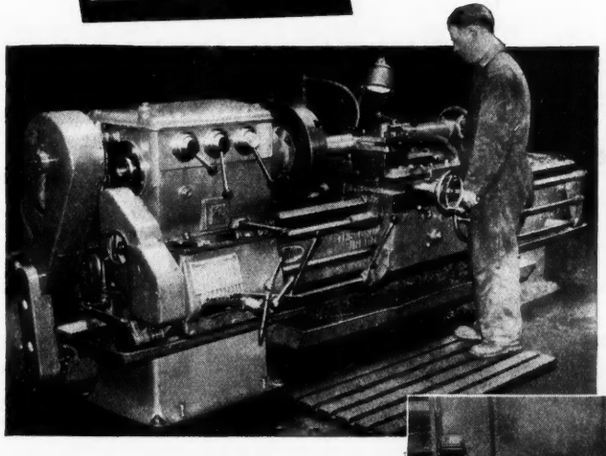
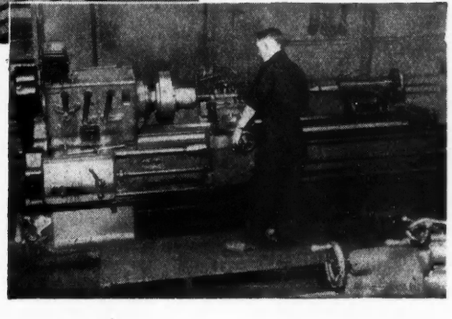


The new Crowthorn 10¼" centre lathe at work.

★

Below: The twelve-years-old Crowthorn lathe.



More than twelve years of hard service, giving complete satisfaction all the time—that is the record of a Crowthorn lathe in the Maintenance Department of Messrs. Woodhead-Monroe Ltd. "The lathe is rigid and sturdy," they say, "and it is possible to work it hard and still maintain close dimensional tolerances."

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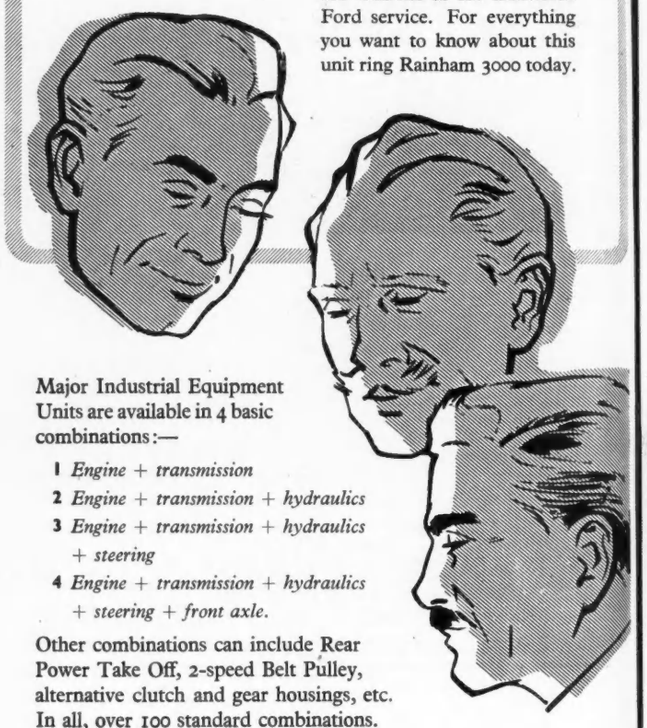

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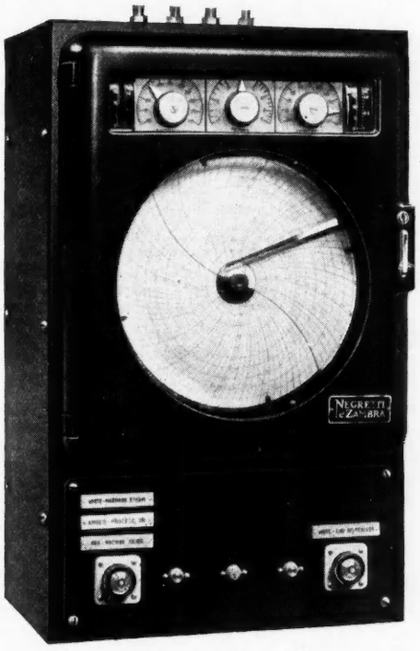
Standardised pneumatic components are arranged in circuit to form an automatic pro-



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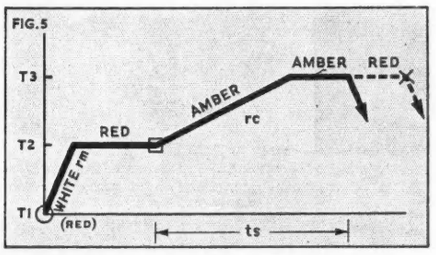

GRAPH shows five temperature changes with corresponding light indicators: (1) Maximum rate of rise to minimum process temperature, when (2) process may be held until (3) controlled rate of rise to maximum is required. (4) Temperature is held until automatic or push-button shut down.

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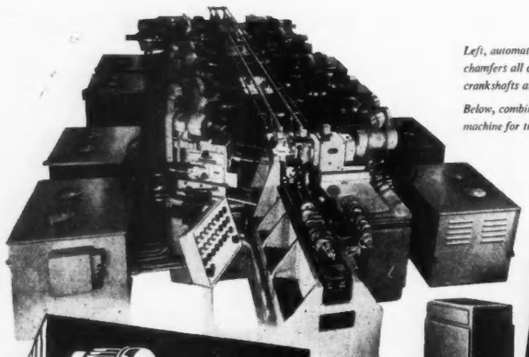

Left, automatic transfer line drills and chamfers all oil ways in 4-cylinder crankshafts at 60 per hour.

Below, combined mill and drilling machine for transmission boxes.

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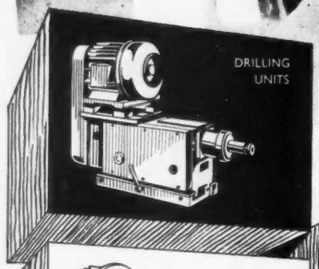

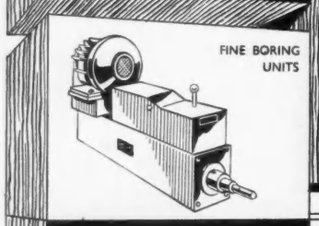

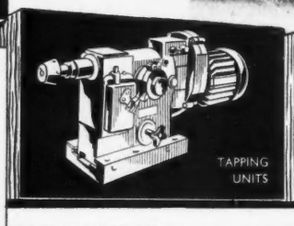

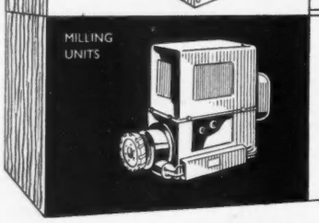

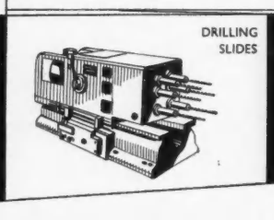

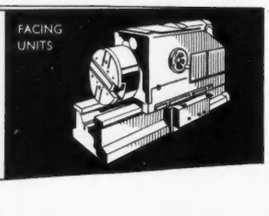

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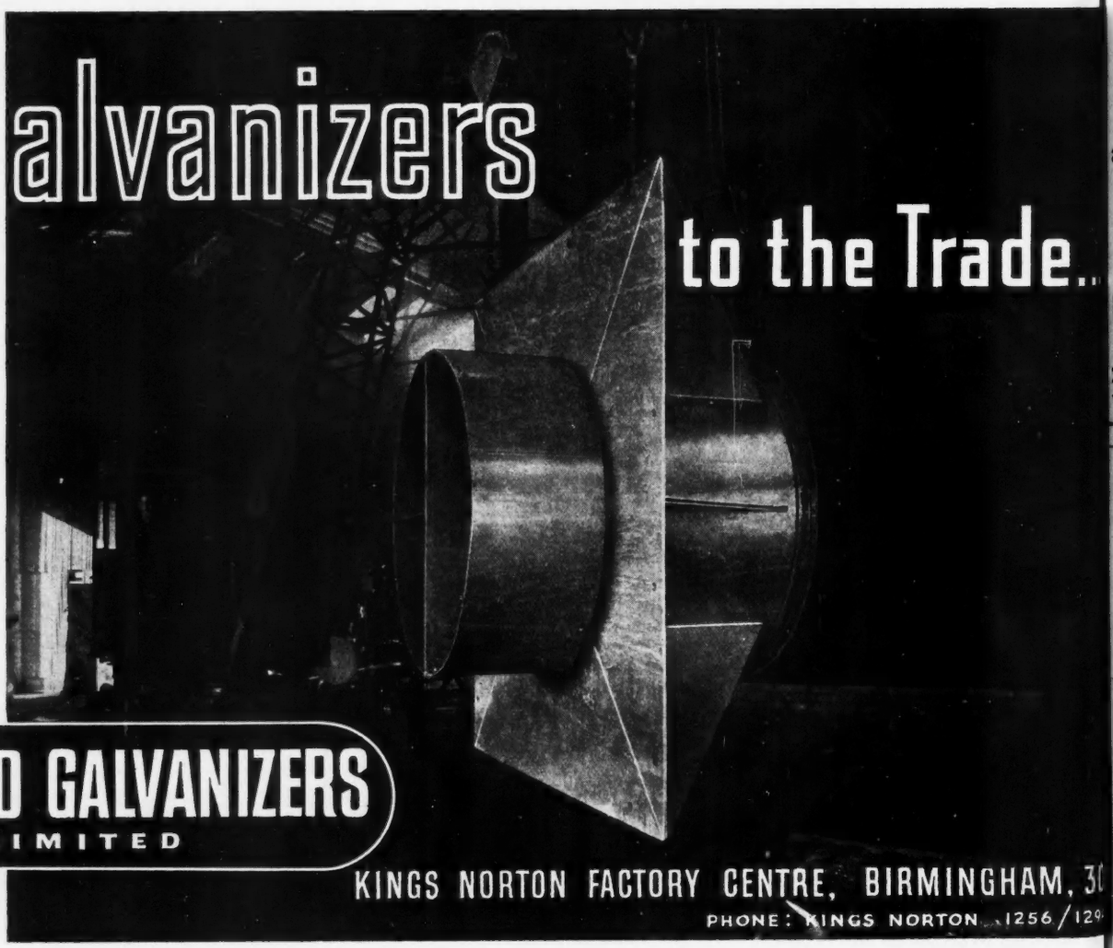

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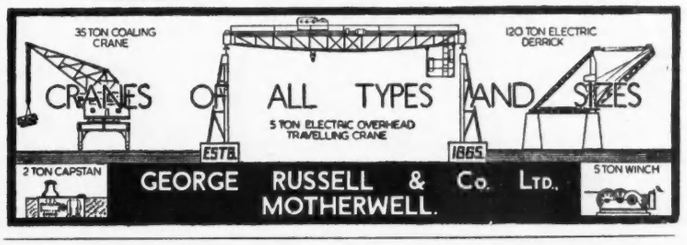

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An Atlas Copco air-driven riveting hammer, type RRN-21, in operation on the overhaul of an A.N.A. airliner. The hammer's well-adjusted striking rate, combined with a high-powered blow, meets the special demands which arise in closing hardened aluminium (duralumin) rivets.

Atlas Copco Air Tools speed Overhauls for Australian National Airways

At Essendon Airport, Melbourne, are the maintenance and base overhaul hangars of Australian National Airways, the largest privately-owned airline company in Australia. There, the 36 aircraft the company owns and operates —DC6-B, DC6, DC4 and DC3 airliners—can be given an overhaul from nose to tail. It is interesting to note that A.N.A. are one of the few airlines in the world who carry out a complete overhaul and reskinning of DC6-B and DC6 airliners.

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